Compressed Air Magazine

MAY 1945

LEADER IN 100-OCTANE OUTPUT

Part of Baytown, Texas, Refinery of Humble Oil and Refining Company

(See Index Page)

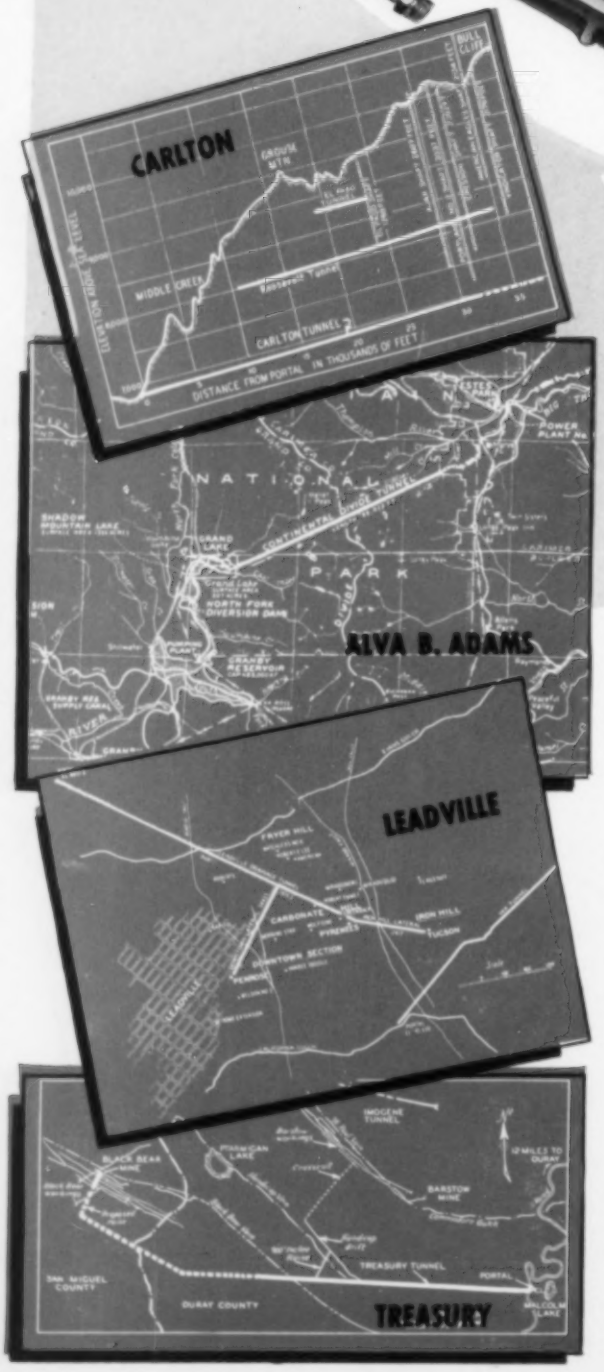
VOLUME 50 • NUMBER 5

NEW YORK • LONDON

MAKING TUNNELING HISTORY

with DA-35

DRIFTERS



The mining and tunneling activity in Colorado and the records established since 1939 are almost unbelievable. All of the history-making projects listed below were driven with DA-35 Power-Feed Drifters. Yes, these machines helped make possible these remarkable feats of tunnel progress. For example, 5 of these drills, working 3 shifts in a 9¼-foot bore, drove 26,400 feet of tunnel from one heading in 513 days. This is indisputable proof of high drilling speed, sturdiness and dependability.

Jackbits and Jackmills were also used on each job. They helped to further increase drilling speed and efficiency. Seven or eight usages were obtained from each Jackbit.

First, there was the 32,000-ft. Carlton Drainage Tunnel, which extended the productive life of the mines in the Cripple Creek district 15 or 20 years.

The 13-mile Alva B. Adams Tunnel, the longest ever driven from two headings, will provide water to prevent the average annual $7,000,000 crop loss.

The Leadville Tunnel — 17,556 feet long — will dewater 3 to 4 million tons of zinc, lead, and manganese ores, and provide a haulage way.

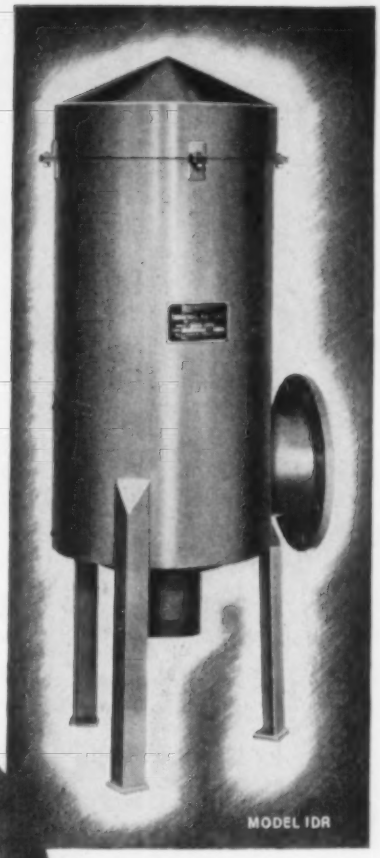
The Treasury Tunnel will drain and make possible the operation of four San Juan mining properties. One of these properties already has 300,000 tons of ore blocked out. This tunnel will also serve as a year-round haulage way.

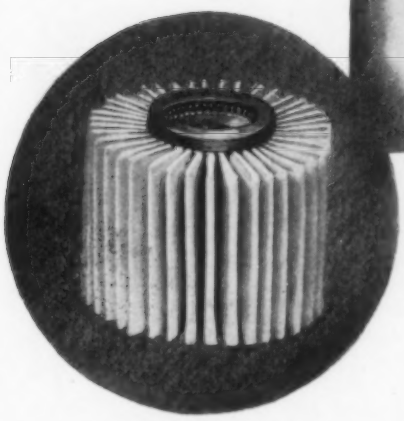
Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y.

5-577

new STAYNEW Intake Air Filter





EXCLUSIVE RADIAL FIN CONSTRUCTION PROVIDES:

- *More Filtering Area
- *Greater Efficiency
- *Less Resistance
- *Less Frequent Servicing

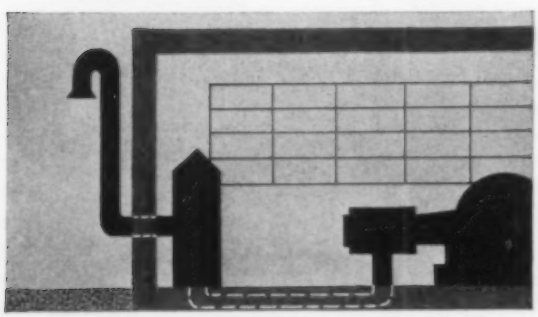
ALL THE CONVENIENCE OF GROUND LEVEL INSTALLATION

ALL THE EFFICIENCY OF HIGH LEVEL AIR INTAKE

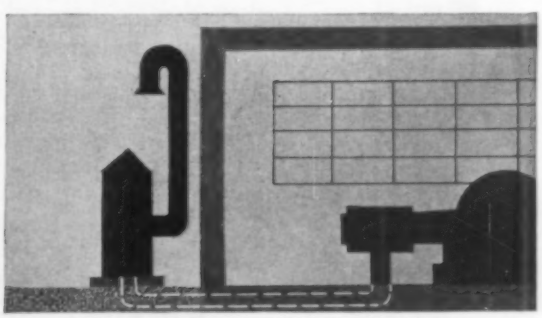
NOW you can equip compressors and internal combustion engines with a Staynew filter providing all the recognized advantages of the famous Protectomotor line . . . *plus* an exclusive combination of two new features.

The new filter, Staynew Model IDR, is so constructed that *installation and servicing can be effected at ground level* (right in the engine room itself if preferred), and the *actual air intake located at the most suitable point.*

Models available with solid base for installation when compressor or engine intake is below floor level.



Model IDR INSIDE Engine Room



Model IDR OUTSIDE Engine Room

Engineering Data on request STAYNEW PROTECTOMOTOR FILTERS Representatives in Principal Cities

DOLLINGER CORPORATION

(Formerly Staynew Filter Corporation)

7 Centre Pk.

Rochester 3, N. Y.

Add life to your wire ropes with LUBRICATION

One of the most frequent causes of premature wire rope failure is lack of proper lubrication. Yet lubrication is such a simple means of extending rope life that it seems incredible that rope users should overlook it. But they do.

Every American Tiger Brand Wire Rope comes to you from the factory, properly lubricated and ready for service. But factory lubrication, no matter how efficient, will not last the life of the rope. Field lubrication at regular intervals is absolutely essential. Wire rope is a machine, composed of many working parts. It requires periodic lubrication to reduce frictional wear.

Use a well-tested lubricant like Tiger-Lube which has been developed through years of study and research. Be sure that the rope surface is clean and that the lubricant is applied uniformly and thoroughly.

Lubrication is insurance against corrosion and is the safest way to prevent excessive internal and external rope wear. Lubrication will materially assist in controlling the wear on sheaves and drums and in prolonging rope life, resulting in increased operating efficiency.

AMERICAN STEEL & WIRE COMPANY
Cleveland, Chicago and New York

COLUMBIA STEEL COMPANY
San Francisco

United States Steel Export Company, New York

Excellay Preformed

UNITED STATES STEEL

Divers Reasons for Effective Lubrication

IT is no exaggeration to say that a diver's life depends upon lubrication. Maintaining his air supply at correct volume and pressure calls for efficient, unfailing compressor operation—impossible without effective lubrication.

The same dependable compressor operation is important, too, for the hundreds of other jobs performed by compressed air. To secure it, operators everywhere know that there are no finer lubricants than Texaco.

Texaco Alcaid, Algol or Ursa Oils, for example, assure wide-opening, tight-shutting compressor valves, free piston rings, open ports, clear air lines, continuous air supply. They also assure maximum service life between overhauls, fewer repairs and replacements. Their use in compressors is worldwide.

Texaco lubricants have proved so effective in service they are definitely preferred in many fields, a few of which are listed at the right.

Texaco Lubrication Engineering Service is available through more than 2300 Texaco distributing plants in the 48 States. Get in touch with the nearest one, or write—

The Texas Company, 135 East 42nd Street, New York 17, N. Y.

THEY PREFER TEXACO

★ More locomotives and railroad cars in the U. S. are lubricated with Texaco than with any other brand.

★ More revenue airline miles in the U. S. are flown with Texaco than with any other brand.

★ More buses, more bus lines and more bus-miles are lubricated with Texaco than with any other brand.

★ More stationary Diesel horsepower in the U. S. is lubricated with Texaco than with any other brand.

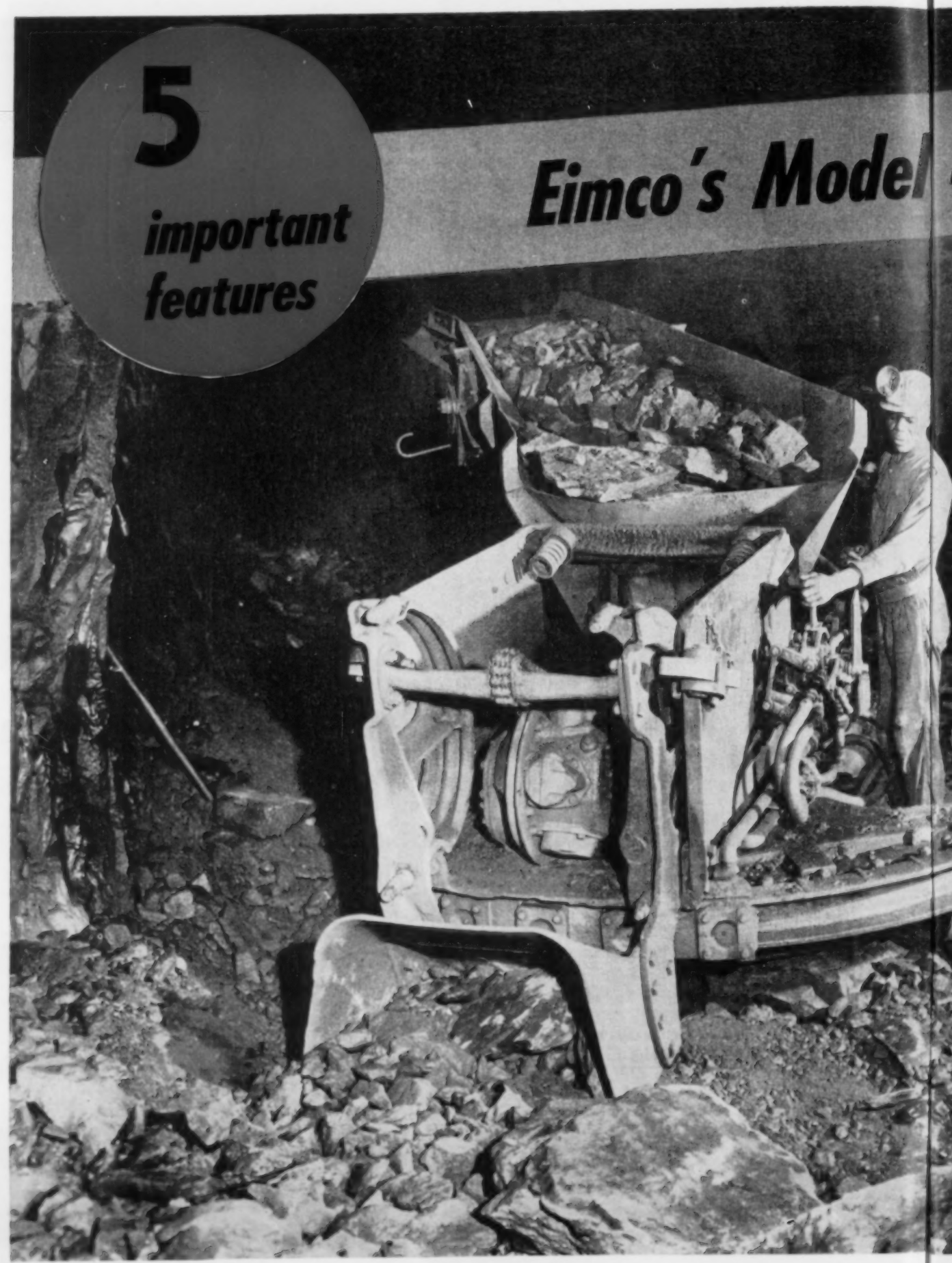
★ More Diesel horsepower on streamlined trains in the U. S. is lubricated with Texaco than with all other brands combined.

TEXACO

TEXACO Lubricants

FOR ALL AIR COMPRESSORS AND TOOLS

TUNE IN THE TEXACO-STAR THEATRE WITH JAMES MELTON EVERY SUNDAY—NIGHT—CBS


5
important
features
Eimco's Model

el 40 RockerShovel

Eimco RockerShovel

Fast Loading

The Model 40 loads directly onto a live conveyor at the rate of 4-5 tons per minute. Average time for loading 6-ton car is about 2 minutes.

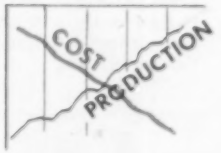
Easy to Operate

Convenient location of control handles, quick response to applied pressures and freedom from foot levers make the Model 40 RockerShovel easy and simple to operate.

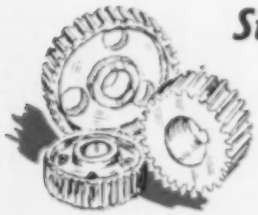
Wide Cleanup

The Model 40 RockerShovel will load rock and ore efficiently from underground headings up to 16 feet in width.

Low Maintenance Cost



Maintenance records kept by reputable companies prove that the Model 40 RockerShovel will operate continuously for long periods of time with a minimum of repairs.



Sturdy Construction

Heavy-duty alloy steel castings, oversize gears, shafts and bearings combined with simple design make the Model 40 the toughest, most dependable piece of underground equipment available today.

EIMCO

THE EIMCO CORPORATION

Executive Offices and Factories: Salt Lake City 8, Utah
Branches: New York, Chicago, El Paso, Sacramento, St. Louis

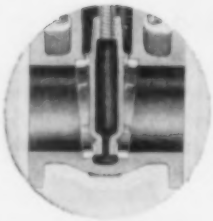
WALWORTH PRESENTS

A New Line of

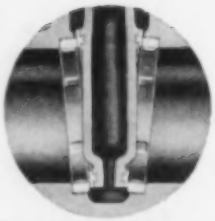
IRON BODY GATE VALVES

with screwed or flanged ends

... 8 Outstanding Features

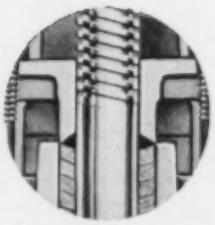


Straight-Flow Port Design reduces fluid turbulence to a practical minimum.



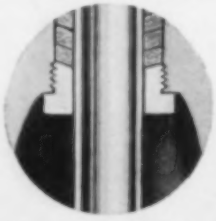
Seat Rings of end-seated type are screwed into the body.

Sure-Grip Malleable handwheel for non-skid gripping even with heavy gloves.

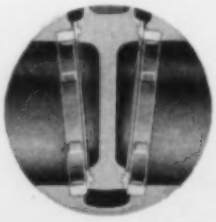


Brass Liner on Glands assures greater resistance to corrosion and scoring.

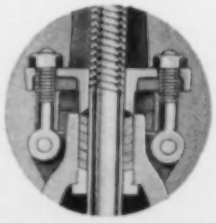
T-head disc-to-stem connection on OS&Y types provides stronger connection, prevents loosening of disc by corrosion.



Bronze back-seat bushings in bonnets of OS&Y valves. (As soon as W.P.B. Limitation order permits.)



Solid Web Type disc in OS&Y valves for greater strength and longer service.



Hinged Gland Eye-Bolts on OS&Y valves permit faster, easier repacking under full pressure.

12 AWARDS
TO 4 PLANTS

WALWORTH

valves and fittings

60 EAST 42nd STREET, NEW YORK 17, N. Y.

For Complete Information on these new Walworth Iron Body Valves, write for bulletin 106.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

TIER-LIFT 4,000 to 10,000 LBS.

The original Tier-Lift, brought out by Lakewood Engineering Co., is the huskiest of all types of high lift trucks. It has a greater lifting capacity in proportion to its dead weight than any other model. It fills an extensive field where loads require high elevation for transfer to storage and where ease and safety of operation are important factors.

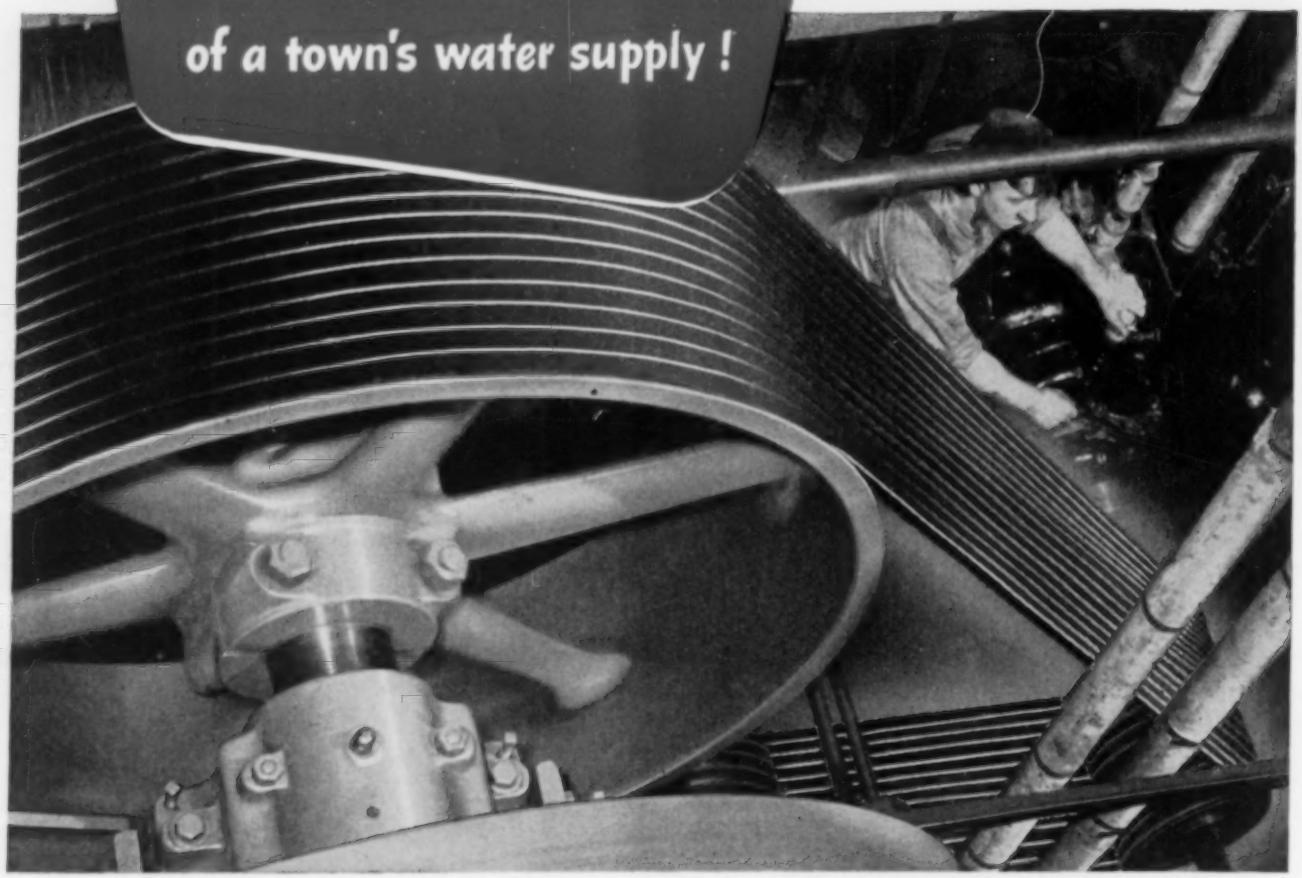
Easton took over Lakewood Engineering Company's truck division in 1931 and since then has carried on the further development of this unique and efficient material handling unit.

Write today: Engineering Counsel, Easton Car and Construction Company, Easton, Pennsylvania.

THE ORIGINAL TIER-LIFT AS NOW BUILT BY **EASTON** A-1007

INDUSTRIAL CARS
TRUCK BODIES · TRAILERS
ELECTRIC LIFT TRUCKS

THE WATCHDOG
of a town's water supply!



- *Tremendous capacity—7,000,000 gallons per day!*
- *Shock absorbing—Saves bearings*
- *Compact drive—Saves floor space*

It's hard to imagine a more important job for a V-Belt drive than providing an uninterrupted water supply for a modern city!

And to insure absolute dependability—the water works officials in Brookline, Mass. called in their Dayton Rubber V-Belt Distributor—who specified this giant V-Belt drive. Thus far, it has seen continuous 7-day-a-week service, for over 4 years, transmitting smooth-flowing power from a pulsating steam engine.

While dependability is the prime requisite in drives of this type—they always deliver many *extra* advantages. For instance, maintenance costs are less. And since it delivers full power (in this case, seven million gallons a day) with less belt tension, bearing wear is greatly reduced. Dayton V-Belt drives permit closer distances between drive and driven centers, thus a more compact installation of power is permitted—saving much valuable floor space.

Your Dayton V-Belt Distributor can bring you advantages like this—in *your* plant. It will pay to investigate

Dayton's three *exclusive* advantages:

1. Dayton Rubber, as World's Largest Manufacturer of V-Belts, offers you vast experience in Power Transmission Engineering.

2. This experience is made available to you through trained specialists in your Dayton V-Belt Distributor's Organization.

3. The technical excellence of Dayton Rubber gives you V-Belts pronounced unsurpassed both in mechanically correct design and in quality of construction.

Call *your* Dayton V-Belt Distributor! Ask how Dayton Power Transmission Engineering can help you.

THE DAYTON RUBBER MANUFACTURING COMPANY
DAYTON 1, OHIO
THE WORLD'S LARGEST MANUFACTURER OF V-BELTS

V-Belts by

Dayton Rubber

REG. TRADE MARK THE DAYTON RUBBER MFG. CO.

THE MARK OF TECHNICAL EXCELLENCE IN SYNTHETIC RUBBER

Reduce cylinder wear

MEMO from CHIEF ENGINEER

Order Cook's Graphitic Iron Piston Rings

AUTHORITIES differ as to the major cause of cylinder wear. But all are in agreement that the cost of cylinder wear together with the expense of cylinder and ring replacements in industrial size Diesels, constitute the major expense item on the maintenance sheet. Assuredly many variables enter the picture, but there is one thing certain—if piston rings could be dispensed with, little wear would occur. It is apparent then, that the piston rings to use are rings specially engineered to minimize wear. COOK has specialized in this all important phase of piston ring development for over 20 years, with the result that COOK'S GRAPHITIC IRON Piston Rings come as near to being frictionless as rings can be. If you do not have the full story of COOK'S GRAPHITIC IRON, write for special bulletin, but better still—to reduce the rate of cylinder wear in your engine, on your next requisition, instruct your buyer to order COOK'S GRAPHITIC IRON Piston Rings. If you need help do not hesitate to call on COOK'S engineers.

Sealing Pressures Since 1889

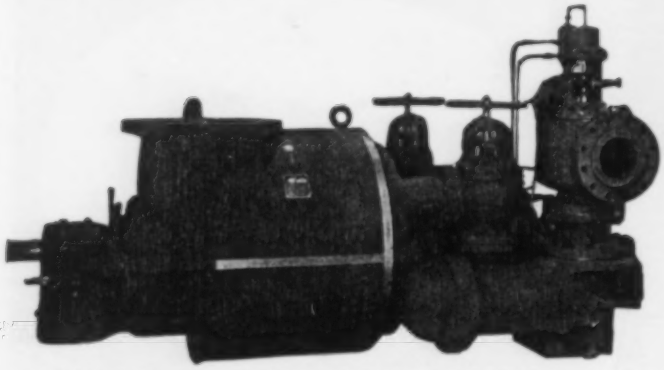
C. LEE COOK MANUFACTURING CO. INCORPORATED

LOUISVILLE, KY.

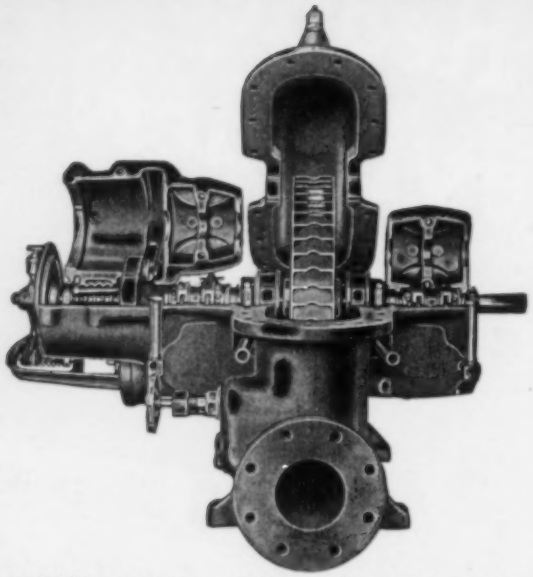
BALTIMORE • BOSTON • CHICAGO • CLEVELAND • HOUSTON • LOS ANGELES • MOBILE • NEW ORLEANS • NEW YORK • SAN FRANCISCO • TULSA

TERRY

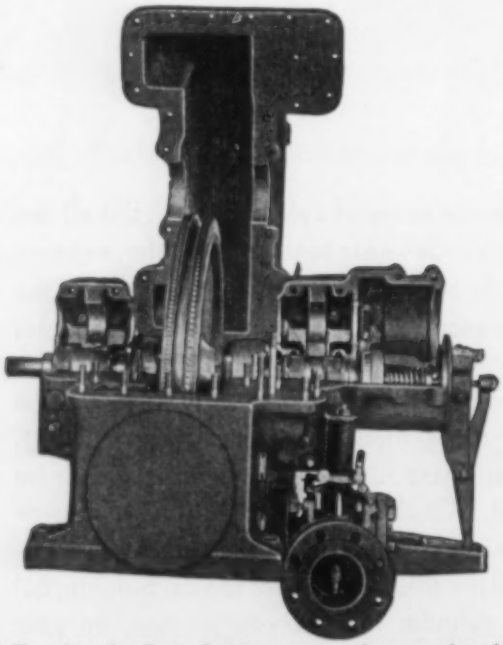
OFFERS COMPLETE COVERAGE OF MECHANICAL DRIVE TURBINES



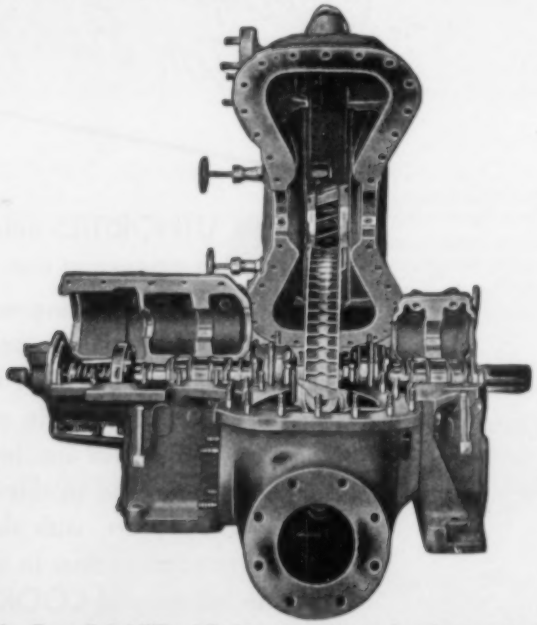
1200 Horsepower Terry Multi-stage Turbine. Units of this type are employed extensively for driving large pumps. The units may be designed for non-condensing, condensing, mixed pressure, or bleeder operation. They may be equipped with constant speed or variable speed governors, remote speed controls or with special governors to meet unusual requirements. Ask for Bulletin SR-114.



Terry Solid Wheel Turbine with Top of Casing Raised. Note the ruggedness and the ease with which the interior parts can be inspected — one of the country's leading oil companies employs 308 of these units for driving various types of refinery pumps. Full details are available in Bulletin S-116.



Axial Flow Impulse Terry Turbine — one of a complete line — built with either two or three rows of blading. These units, like all Terry turbines, are the result of over 45 years of successful experience in the manufacture of turbine drives exclusively. Completely described in Bulletin S-107.



Twelve Terry Solid Wheel Turbines, similar to the above unit, drive auxiliaries in the power house of an east coast refiner. They operate with steam at 625 lbs. pressure — 700° Total Temperature. Eight of the machines exhaust against 125 lb. back pressure. The first of these units was purchased in 1931. It proved entirely satisfactory so that as the plant was enlarged, duplicate Terry's were added. Bulletin S-99.

T-1151

THE TERRY STEAM TURBINE CO.

TERRY SQUARE HARTFORD, CONN.

The light is always green at POWELL

At Powell, scientific study, research and experimentation *never* STOP. That's why Powell Engineering has always been able to solve the intricate flow control problems imposed by new products and processes.

Add to this our non-stop application of lessons learned through 99 years of practical experience and you have the Powell Line—a complete line of valves of every type and material needed to satisfy all flow-control requirements of industry today. And tomorrow, as new demands arise, there'll be Powell Valves to meet them.

Fig. 1793—Iron Body Bronze Mounted Gate Valve for 125 pounds W. S. P. Has flanged ends, outside screw rising stem, bolted flanged yoke and taper wedge solid disc. Also available with taper wedge double disc—Fig. 1444.

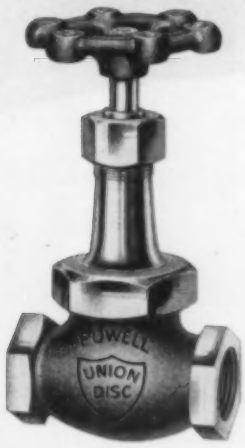


Fig. 150—Bronze Globe Valve for 150 pounds W. S. P. Has screwed ends, union bonnet and vulcanized, composition disc.

Fig. 95—Bronze Dash Pot Check Valve for 200 pounds air working pressure. Designed for air compressor service. Has screwed ends, screwed cap, and regrindable, renewable nickel-bronze disc. Because of the cushioning effect of the plunger in the dash pot, the seating of the disc is practically noiseless.

Fig. 241—Iron Body Bronze Mounted Globe Valve for 125 pounds W. S. P. Has flanged ends, outside screw rising stem, bolted flanged yoke and regrindable, renewable bronze seat and disc.

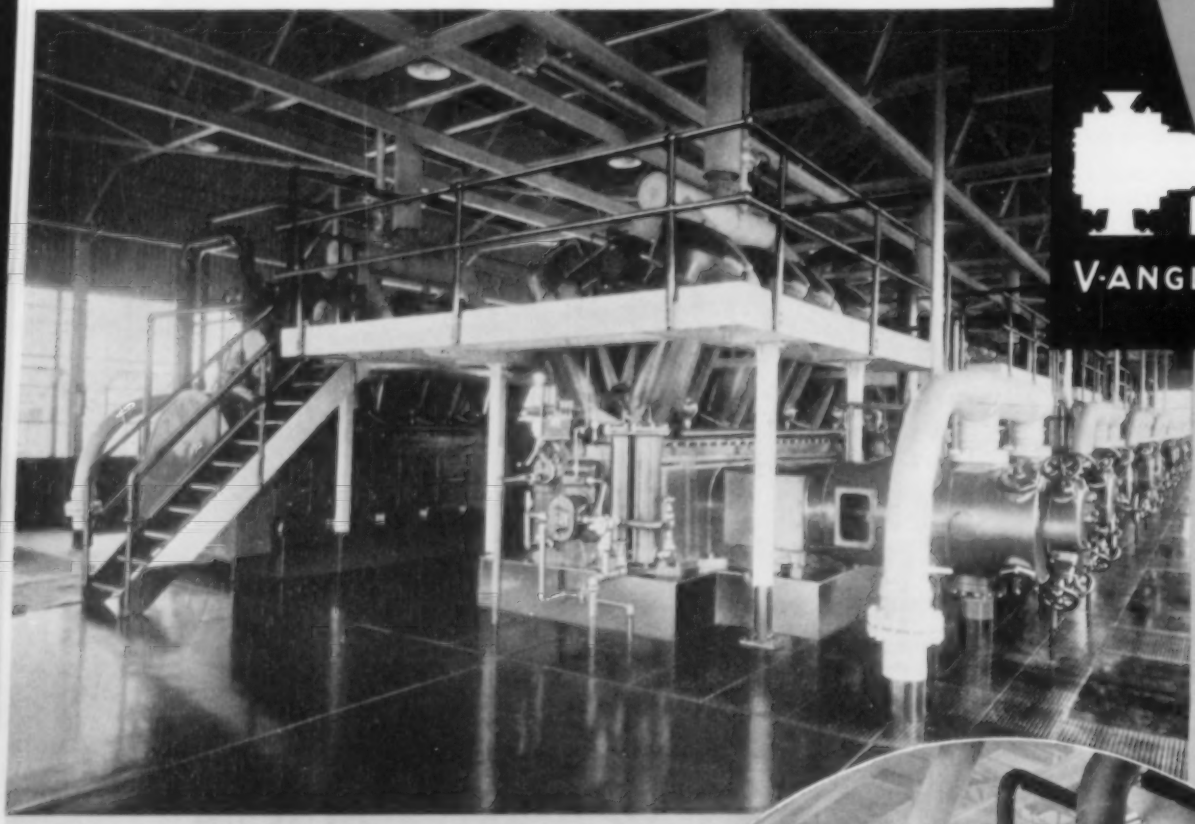
The Wm. Powell Co.

Dependable Valves Since 1846

Cincinnati 22, Ohio

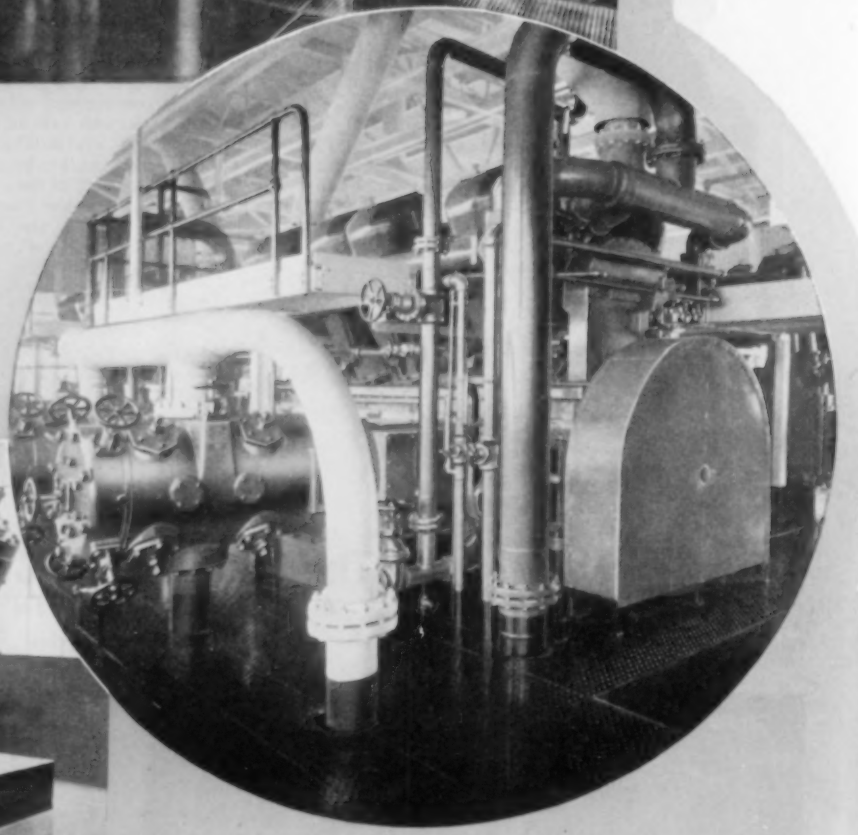
POWELL VALVES

MORE AND MORE 4-CYCLE...

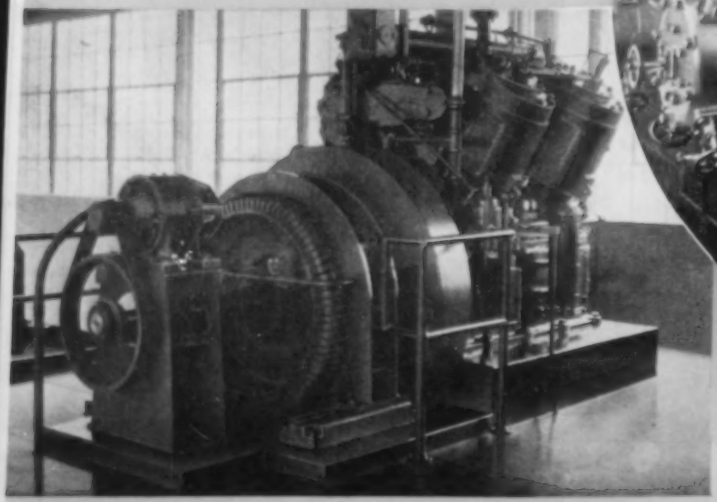


(Above) General view of the compressor room, Hansford Station. Six of these units were installed in 1941, two in '42, four in '43, and two in '44.

In the Hansford Station of Panhandle Eastern Pipe Line Company, are fifteen 4-cycle V-angle units totaling 10,185 hp. This station is 100% I-R equipped (including all pumps and starting-air compressors) except for two generator units which were moved from the Liberal Station where they were replaced by the PVG engine-generator units shown on the opposite page.



(Above) Close-up of the new 800-hp KVG compressors at Hansford Station.



(Left) A 185-hp PVG gas engine in the Hansford Station.

COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO-BLOWERS

Gas-Engine-Driven Compressors & Engines

in the Panhandle Eastern System

Twenty-eight Ingersoll-Rand gas-engine-driven compressors and generators, totaling nearly 20,000 horsepower, are now serving the Panhandle-Eastern Pipe Line system. All of these are modern, 4-cycle V-angle units installed during the past nine years. More than 11,000 horsepower of this total capacity consists of 800-hp KVG compressors serving in recently enlarged stations.

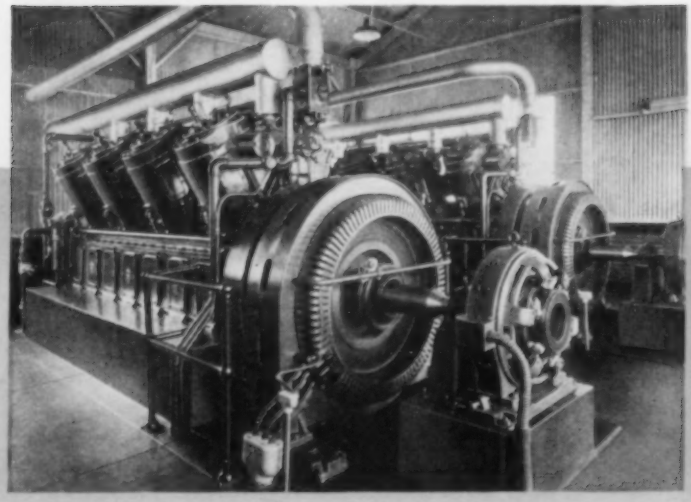
We are confident that the faithful and economical performance of these engines and compressors will point the way to more and still more 4-cycle V-angle units in the future expansion of this system.

Ingersoll-Rand

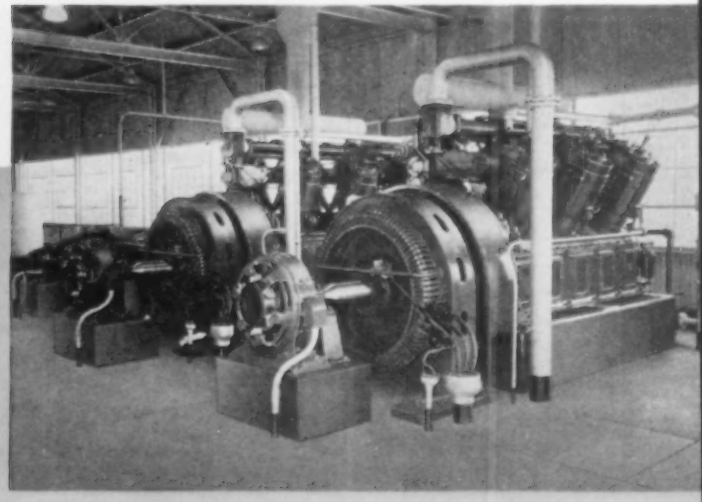
11 BROADWAY, NEW YORK 4, N. Y.

6-580

The first 4-cycle V-angles in the system were two 370-hp PVG engines installed at Liberal in 1936.

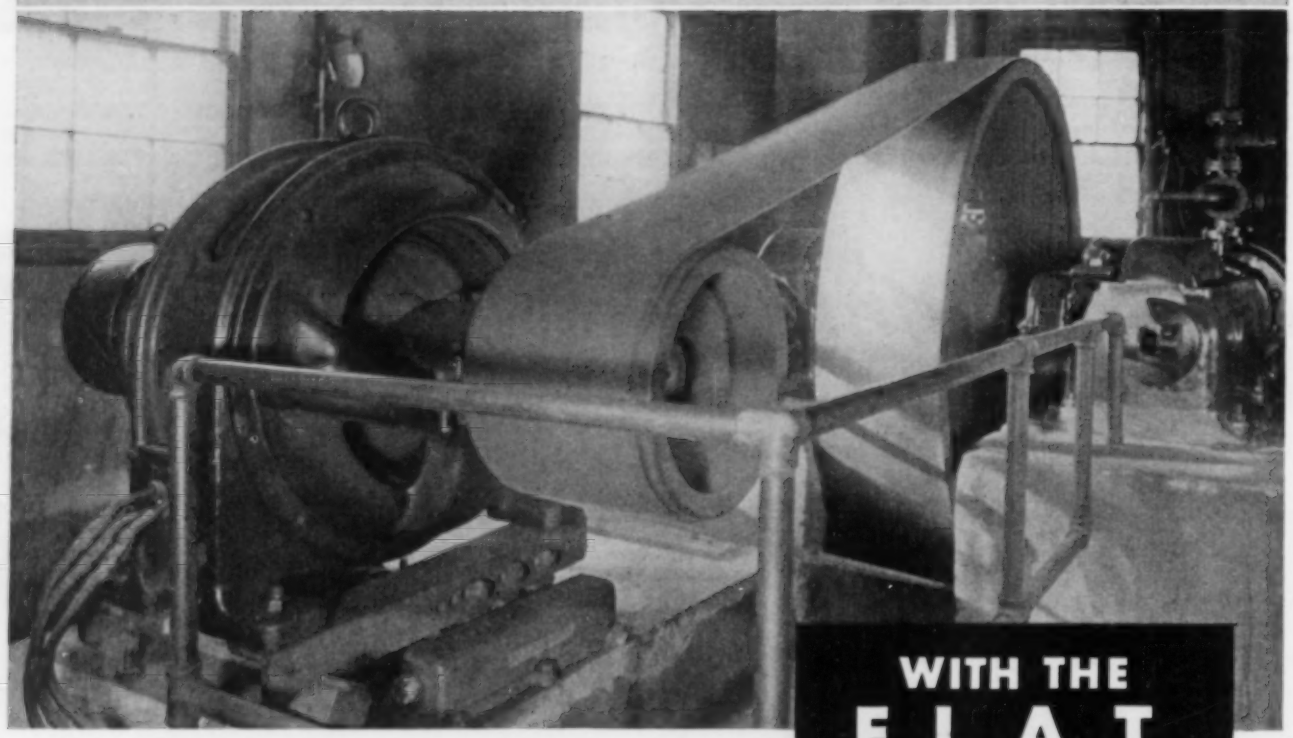


The first repeat order . . . two 275-hp gas engines installed at Tuscola in 1937.



CONDENSERS • CENTRIFUGAL PUMPS • OIL AND GAS ENGINES

SAVE space, power and replacement costs



The **Flat Leather Automatic Tension** drive with Graton & Knight **"Research"** leather belting offers many advantages to compressor users.

AUTOMATIC TENSION

While it is necessary in most drives to increase the belt tension to accommodate short centers, in the **F. L. A. T.** drive the tension is automatically adjusted to match the load. Guesswork has been eliminated.

SHORTER CENTERS

The pivoted base permits smaller arc of contact on the driving pulley, thus reducing necessary center distance between motor and compressor pulleys.

LONG LIFE

A **"Research"** belt on the **F. L. A. T.** drive will outlast a rubber V-belt by 2 to 1. Full details are given in Leather Belting Manual. Write Graton & Knight Company, 365 Franklin St., Worcester 4, Mass.

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ON THE COVER

THIS picture was taken at the largest oil refinery in the country. In the foreground are superfractionator towers. Spheroid tanks are in the middleground, and in the left background is the No. 2 Fluid Catalytic-Cracking unit. On December 14, 1944, this Humble refinery at Baytown celebrated the production of its billionth gallon of 100-octane gasoline, being the first in the nation to attain that figure. Up to that time it had also furnished other plants with 250,000 gallons of aviation-gasoline components.

Immediately following the Pearl Harbor attack, when our supply of aviation gasoline was short, the Baytown refinery was producing 1 gallon of every 5 gallons made in the country. Its facilities have been expanded since then, and despite the vast construction program by other refiners, the Baytown plant accounted for 10 percent of the nation's 1944 output of this superfuel. In addition, it produced more toluene (used in making TNT for bombs) up to the beginning of this year than was manufactured in the entire United States during all of World War I. It is also turning out annually 45,000 tons of butadiene for making Buna-S synthetic rubber. Other principal war products are 80-octane all-purpose gasoline, heavy-duty lubricants for military equipment, diesel-engine fuels, solvents, and Navy fuel oil.

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Compressed Air Magazine

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C. H. VIVIAN, *Editor* J. W. YOUNG, *Director of Advertising*
ANNA M. HOFFMANN, *Assistant Editor* J. J. KATARBA, *Advertising Mgr.*
D. Y. MARSHALL, *Europe*, 243 Upper Thames St., London, E.C.4.
F. A. MCLEAN, *Canada*, New Birks Building, Montreal, Quebec.

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Fishways for Fraser River Salmon

Copeland Lake

FOR a sum of money that seems trivial, compared with the huge outlays made for destructive warfare, the United States and Canada are jointly building fishways on the Fraser River in British Columbia that will return each year in increased salmon yield many times their total cost. The fishways will permit sockeye salmon, bent upon returning to their upstream spawning grounds, to negotiate Hell's Gate, a turbulent narrows beset with obstacles placed there by Nature and augmented by railroad construction which began in the canyon in 1911. Since that time few of the spawners have been able to pass that point, and vast numbers of them have died annually without procreating their kind. Millions of dollars worth of desirable food fish have consequently been lost.

At Hell's Gate, 130 miles upstream from the Fraser's mouth, the river becomes "white water" as it rushes through a constricted throat whose walls are as little as 110 feet apart. This 1500-foot stretch is a part of the canyon section by which the stream passes from an inland plateau through the coastal mountains. The Fraser drains an area of 90,000 square miles—equivalent to three Scotlands or two Pennsylvanias. In the spring and summer melting snows swell its volume, and as it tumbles through Hell's Gate it sometimes attains a depth of 90 feet and a flow of 20 miles per hour.

In 1807, explorer Simon Fraser, for whom the river is named, called Hell's Gate "a place where no human should venture." He was traveling downstream at the time, and declared that the canyon walls were so rough that it was impossible to transport canoes along them. Accordingly, he set the boats adrift and prayed to Providence to take them through. Some were recovered downstream; others were smashed to pieces. The hardy empire builders who came

ROCK DRILLERS AT HELL'S GATE

No more spectacular natural setting for a construction job than this one could be imagined. These pictures, taken at low water, give a hint of the savage power of the Fraser River when it reaches full flood stage of around 90 feet. The view at the left-bottom shows Jackhamer operators doing preliminary drilling on a shelf just above the raging stream. Jackbits and drillrods, which greatly reduce drill-steel transportation on jobs such as this one, may be seen between the two men. The same area, taken from across the river, is pictured above. The contractor is using ten Jackhamers and a number of sinkers, drifters, and wagon drills on this diversified job. Compressed air is supplied by 105-, 210-, and 315-cfm. portables. At the top-left is a close-up of a heavy sinker drill made by converting a drifter.

along a century after Fraser had less respect than he for the austerity of Hell's Gate. They not only traveled its precipitous walls but also laid steel rails on them. The Canadian Pacific tracks run on one bank and the Canadian National on the other, both of them 100 feet above the stream. During the construction work on the latter there was precipitated a rock slide that strewed additional thousands of tons of boulders in the already partially choked river channel. Some blasting was done to remove the obstructions, but from that time on the lucrative salmon-fishing industry along the Fraser registered a sharp decline.

During the early years of this century as many as twenty canneries were operated along the waterway, and they accounted for a large proportion of British Columbia's total revenue from fisheries. In 1913 the Fraser salmon pack amounted to a record 2,401,000 cans of 48 pounds each. At today's inflated prices it would be worth around $50,000,000, and at the more nearly normal 1940 figures it would sell for $38,000,000. The sockeye spawns every four years, hence the number returning upstream fluctuates from year to year. Another large catch was indicated in 1917, but it actually came to only 600,000 cases, or less than 25 percent of the 1913 pack.

Even then it was not generally agreed that the Hell's Gate bottleneck was wholly responsible for the drop. For some years previously there were those who claimed that the river was being overfished, and there was consequently a tendency to blame the smaller yield on this. It gradually became clear, however, that the real cause was the failure of most of the spawners to get back to the waters where they had come into being, there to deposit eggs to perpetuate their species and then to die.

It was apparent that something would have to be done to make Hell's Gate navigable for salmon. The Fraser lies wholly within Canada and empties into the Strait of Georgia. American fishermen had always taken half or more of the catch while the fish were making their way from the ocean to the river. It was felt, therefore, that the restoration of the stream should be a cooperative endeavor by the two nations. Canada showed willingness to do its share, but it took a long time to get the United States to participate. In 1919 the government at Ottawa approved a proposal to appoint an international commission to handle the problem, but the U. S. Senate failed to ratify it.

During the next ten years Canada made other efforts to obtain a working agreement, but America did not respond despite the fact that the yield of salmon from the Fraser continued low. One reason why our fishing interests opposed the compact was because the proposed international accord provided that the two nations should share the Fraser salmon pack on an equal basis and the

Keystone Photo

SALMON FORGING UPSTREAM

The salmon gets its name from the Latin "salmo," meaning the leaper. In normal times, the color of the meat has a bearing on the price of the canned product, and the brilliant-red sockeye commands top figures. The Indians knew this fish as the "Saw-qui," and it is easy to see how the word became Sockeye. The redman valued each fish at one cent, whereas today 6 or 7 pounds of tinned sockeye will bring several dollars. The flesh of the fish is silvery when it comes in from the sea on its way to the spawning grounds. When it reaches fresh water it turns pink and then deepens to a characteristic red.

United States had often been getting more than half of it. During that time, conservationists in the State of Washington succeeded in getting a bill passed that prohibited the use of salmon traps and fixed gear in the waters of that state. Under this law the American catch dwindled, and our fishermen began to see that the 50-50 division suggested by the Canadians was really fair to both sides. In 1937 the agreement was ratified in both Washington and Ottawa, and there was created the International Pacific Salmon Fisheries Commission composed of three members from each of the two nations. The present chairman of the body is Edward W. Allen of Seattle, Wash. Other United States members are Fred J. Foster, of Seattle, and Charles E. Jackson of the Fish and Wildlife Service, Washington, D.C. Canadian representatives are A. L. Hager, Vancouver, B. C.; Tom Reid, New Westminster, B. C.; and A. J. Whitmore, Department of Fisheries, Ottawa, Ont.

The commission was given eight years to study the Fraser sockeye-salmon fishery and to plan its revival. Limited funds were made available for experimental work. Its first step was to retain as director of its investigators Dr. Will F. Thompson, now head of the school of fisheries of the University of Washington. He had previously attained distinction for his studies of the west-coast halibut fisheries in behalf of another Canadian-American commission.

Doctor Thompson set out to ascertain definitely what effect Hell's Gate was having on the decreased Fraser salmon catch. This was done by tagging adult fish so that their movements could be traced. For seven years taggers have obtained salmon from the river at Hell's Gate and attached a small, numbered celluloid disk to the dorsal fin of each one. The fish were then released. Just how many went through their hands in that interval has not been revealed, but up to the end of 1942 they tagged 34,124 adult salmon from which 10,663 tags were recovered. To insure return of the tags they offered 25 cents apiece for them. Commercial fishermen coöperated well with the commission, and even the Indians eagerly turned in those that came into their possession, though they didn't understand why anybody wanted them badly enough to pay for them. As a result of this work it was proved conclusively that something would have to be done to ease the way for the fish past Hell's Gate.

The investigation showed that it was virtually impossible for salmon to make their way upstream when the river at Hell's Gate was between 25 and 45 feet deep. When the flow was below or above that range some fish got through, but there were years when the stream was at the impassable stage throughout nearly all the salmon season from July to December. The sockeye comes into the Fraser a bright silver color, and as it swims upstream it turns pink and then red. As soon as it approaches fresh water it stops eating, and its fast lasts until death. It may travel for as many as 60 days to reach its spawning grounds, and during that interval it lives on fat previously stored up in its body. The farther it goes, the weaker it gets, and if it is held up a long time by a blockade at Hell's Gate it may not have the strength to proceed even though the stream flow becomes favorable.

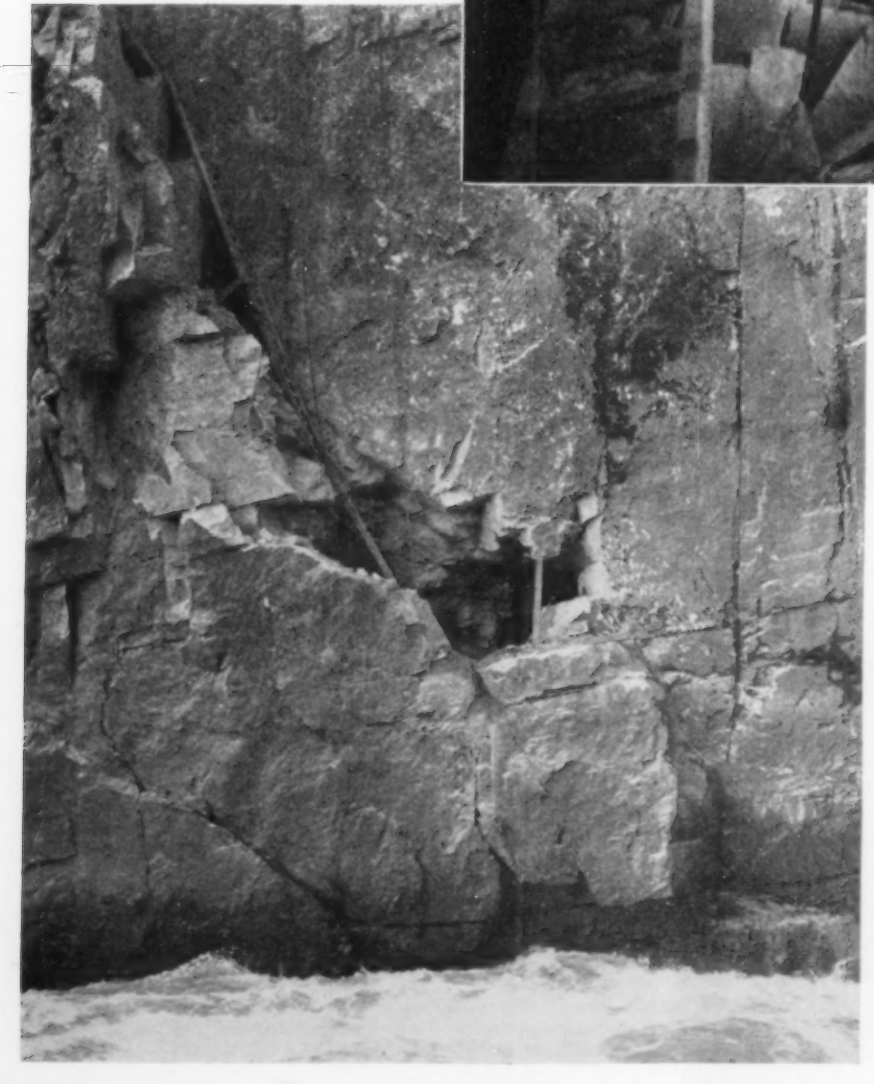
The tags proved that some years, when the Gate was closed for long

CONSTRUCTION CAMP

Above the river, on the west bank, the contractor has set up the necessary facilities for carrying on the work. The camp was in the early construction stages when this picture was taken. The buildings at the top are along the Canadian Pacific Railway tracks.

periods, millions of fish choked the river below it, remaining there until exhausted and then dying. In 1941, salmon accumulated for a distance of 6 to 7 miles below Hell's Gate, and their progress was blocked for 36 consecutive days. Then there was an interval of one or two days when the stream was open, after which there was another 31-day blockade. Most of the spawners that reached the headwaters went through Hell's Gate during that brief interval. Relatively few of the total number made it, and a disappointing catch in 1945 is forecast as a result.

In addition to tagging salmon, the commission made a study of the type of fishway that would be required at Hell's Gate. In Seattle, the commission's consulting engineer, Prof. Charles W. Harris of the University of Washington, working with Walter Hiltner of the same institution and Prof. E. S. Pretious of the University of British Columbia, built a concrete scale model of Hell's Gate one-fiftieth actual size. With it, they could reënact the river's

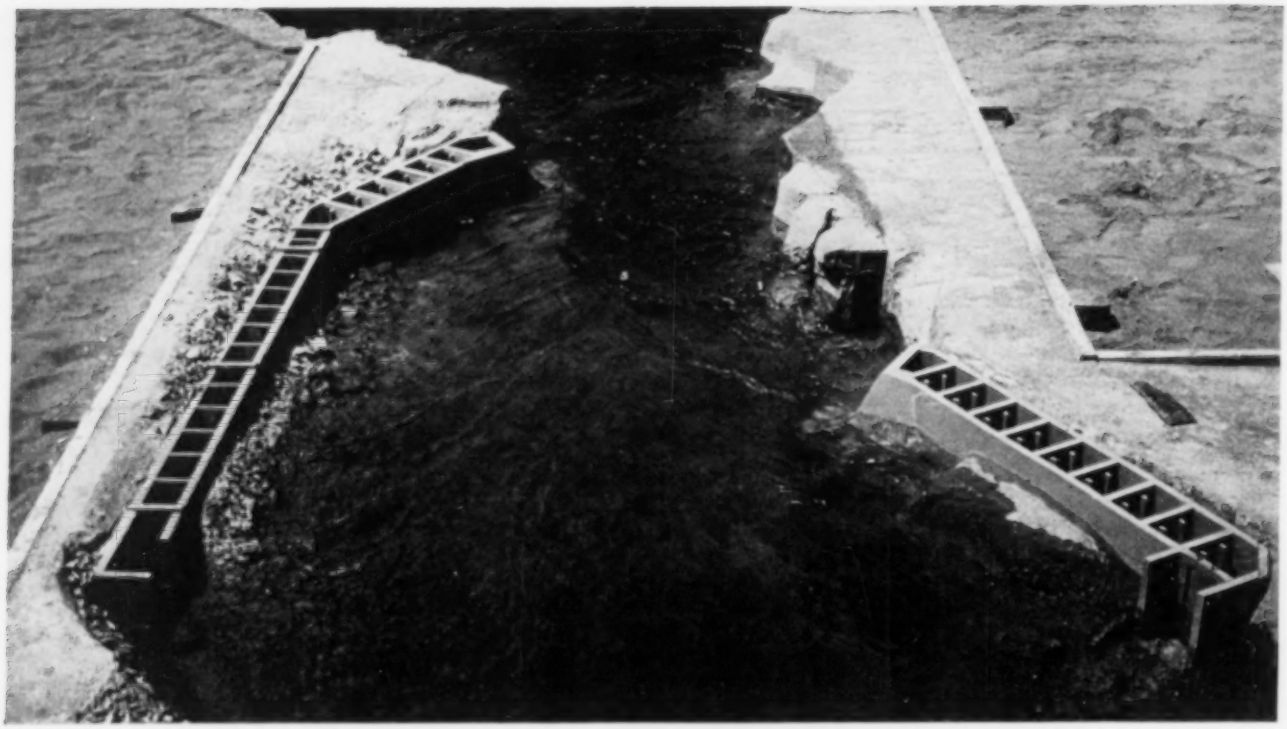


PORTAL OF TUNNEL

A tunnel that will connect with the lower end of the fishway is being driven downstream through the rock wall on the west side of the river. It will be 135 feet long, 12 feet wide, and 40 feet high. When the water is deep enough to enter the tunnel, fish will swim up through it and emerge to find themselves at the base of the concrete structure designed to ease their way through the remaining stretch of swift water. These pictures show the entrance from which tunneling is being done. The one at the left was taken from across the river. The workmen travel up and down 100 feet by ladders.

tumultuous flow, down to the last swirl. Their experiments disclosed that conventional-type fish ladders, with pools arranged in a series of steps, would not be suitable at Hell's Gate because of the 80-foot variation in stream level in some years. They consequently designed an all-swimming fishway that the salmon can negotiate without the need of making a single jump. There will be one of these on either side of the stream, each a concrete structure with baffles 18 feet apart.

As explained by Professor Harris, "Each baffle makes a resting pool for the sockeye. There will be a two-foot gap on either side of the baffle for the fish to scoot through into the next resting pool. They can progress up several



MODEL OF FISHWAYS

This 1-to-50-scale replica of the river at Hell's Gate was erected at the University of Washington for detailed study. The fishway models were added later. This is a downstream view. Beyond the fishway on the right or west bank may be seen the upstream end of the tunnel that will permit salmon to by-pass the lower part of the rapids.

baffles at one time or stop and rest at each pool, according to their strength. We know that the velocity of the river will be so retarded in the baffles that the fish will go up without over-exerting." Appropriations of $1,000,000 each were made by the Canadian and United States governments to finance the commission's operations. A large part of this fund is being spent at Hell's Gate, the remainder will be used in removing a number of lesser obstructions in the Fraser River and its tributaries.

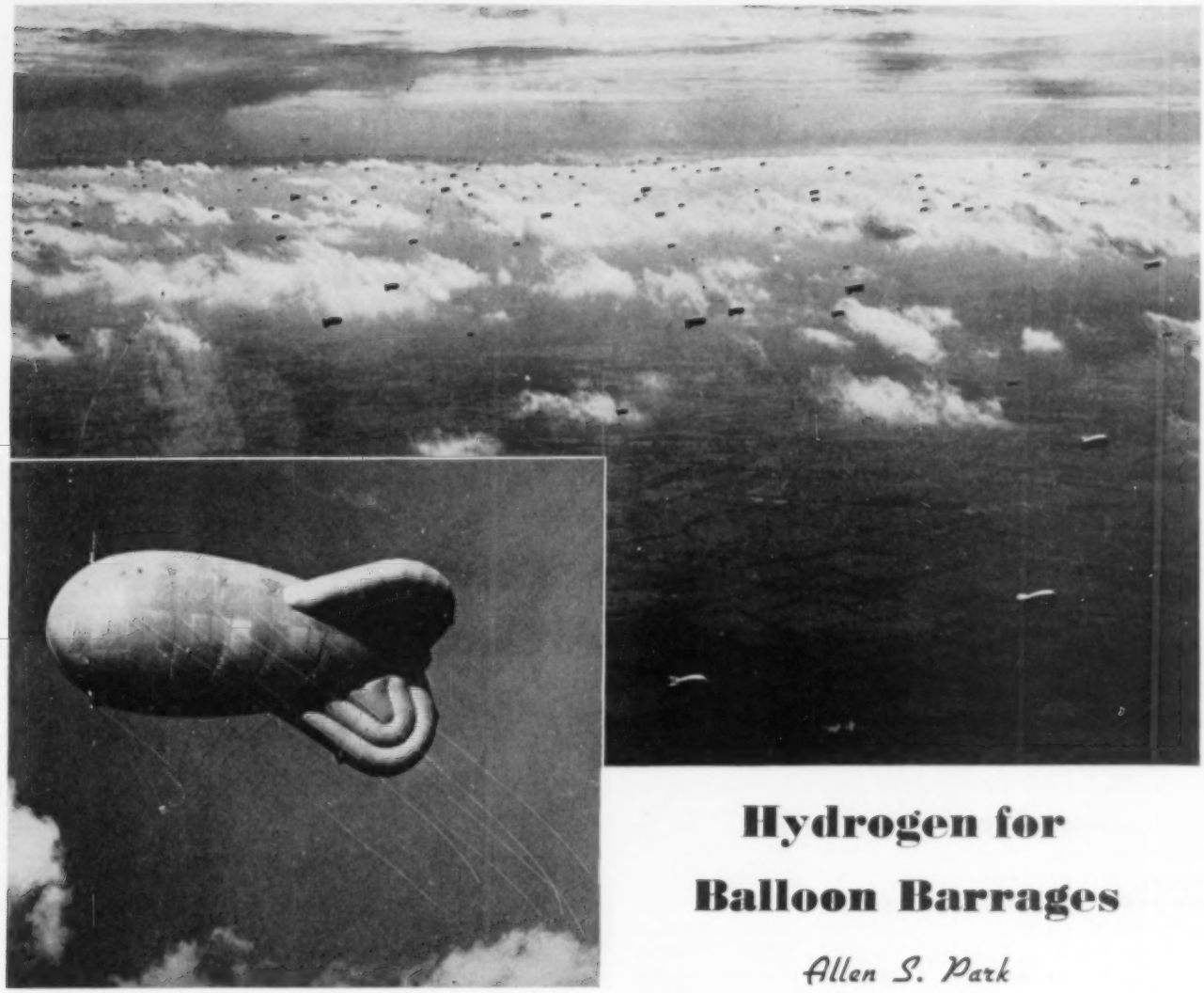
The work at Hell's Gate is being done by the Coast Construction Company, Ltd., of Vancouver, and has been in progress since last fall. On the west bank it is building a fishway 220 feet long and 20 feet wide, with ten pools. Just downstream from its lower end an inclined tunnel is being driven in the rock wall to provide further aid to the salmon. The tunnel will be 135 feet long, 42 feet high, and 12 feet wide. On the east side the fishway will be in two sections. The lower one will be 160 feet long, 20 feet wide, and have seven pools; the upper one will be 300 feet long, 12 feet wide, and have fifteen pools. The west fishway is expected to be usable by salmon when the river surface is between 20 and 50 feet above bed elevation and the other one when there is between 23 and 50 feet of water. As the stream has an average rise to 60 feet and a maximum rise to 93 feet the fishways will be entirely underwater during parts of every summer. The contractors can work, of course, only during the low-water season.

It is necessary to use every precaution lest further slides be started that will add to the obstructions in the river. In fact, every effort is made to keep even the smallest of rocks from tumbling into the stream. Rock drills are being utilized, but blasting is on a reduced scale that the men call "baby-breath" shooting. Loose rock is being carefully removed, and it is estimated that 34,000 cubic yards of it will be handled. Excavation in solid rock is placed at 18,000 cubic yards. All these materials are being hauled away in trucks and by a short railway on which cars are moved by cable with power from a hoisting engine. Some telegraph lines have been relocated, but the work has been done without interfering with train operations. The contract involves the placing of 7475 cubic yards of concrete, 10,000 cubic yards of backfill, and 2600 cubic yards of riprap. Construction will require 875,000 pounds of reinforcing steel and 225,000 pounds of structural steel.

Mr. Milo Bell, an American engineer who has specialized in the building of structures to carry salmon runs past natural and man-made obstructions, is serving as chief engineer for the commission. B. M. Brennan, director of the commission, has general charge of the operations. The contractor's work is being directed by James A. Collins, president of the firm. More than 100 men are employed on the project, and a miniature village has been set up on the west bank of the river to house them and to provide the necessary shop facilities. It is expected that the fishways will be partially operative this summer. Work will have to be suspended during the high-water period, but it will be resumed late next fall.

The salmon pack on the Fraser has averaged 196,000 cases annually during the past 25 years. The experts who made the study for the commission predict that when the fishways are functioning it will rise to 750,000 cases. They expect "big-cycle" yields of up to 2,000,000 cases and "off-year" catches of around 500,000 cases. At present prices the increased yield will be worth $16,000,000, which is equivalent to more than 40 percent of British Columbia's 1942 fish production which, in turn, was more than half of the total for Canada.

The rehabilitation of the Fraser sockeye industry will mean much to the economy of the area concerned. About 1300 persons are given employment for every 100,000 cases of salmon packed. On this basis, the expected increase in yield will, if it materializes, put more than 7000 people to work. No one knows how much money has been irretrievably lost through failure to attack the Hell's Gate problem sooner. Estimates range all the way from $200,000,000 to more than $1,000,000,000. It seems certain, however, that few postwar undertakings will give a greater return than this one on every dollar spent.



Hydrogen for Balloon Barrages

Allen S. Park

British Official Photos

A BARRIER OF GAS BAGS

During last year's 80-day attack by flying bombs, Britain marshaled 2000 barrage balloons to protect London and southern England. It was the greatest defense system of its kind ever assembled, and brought down 279 of the 8000 robot bombs launched by the enemy. A section of the barrage is shown stretching as far as the eye can see. In the inset is a close-up of one of the balloons, with its network of suspended wires.

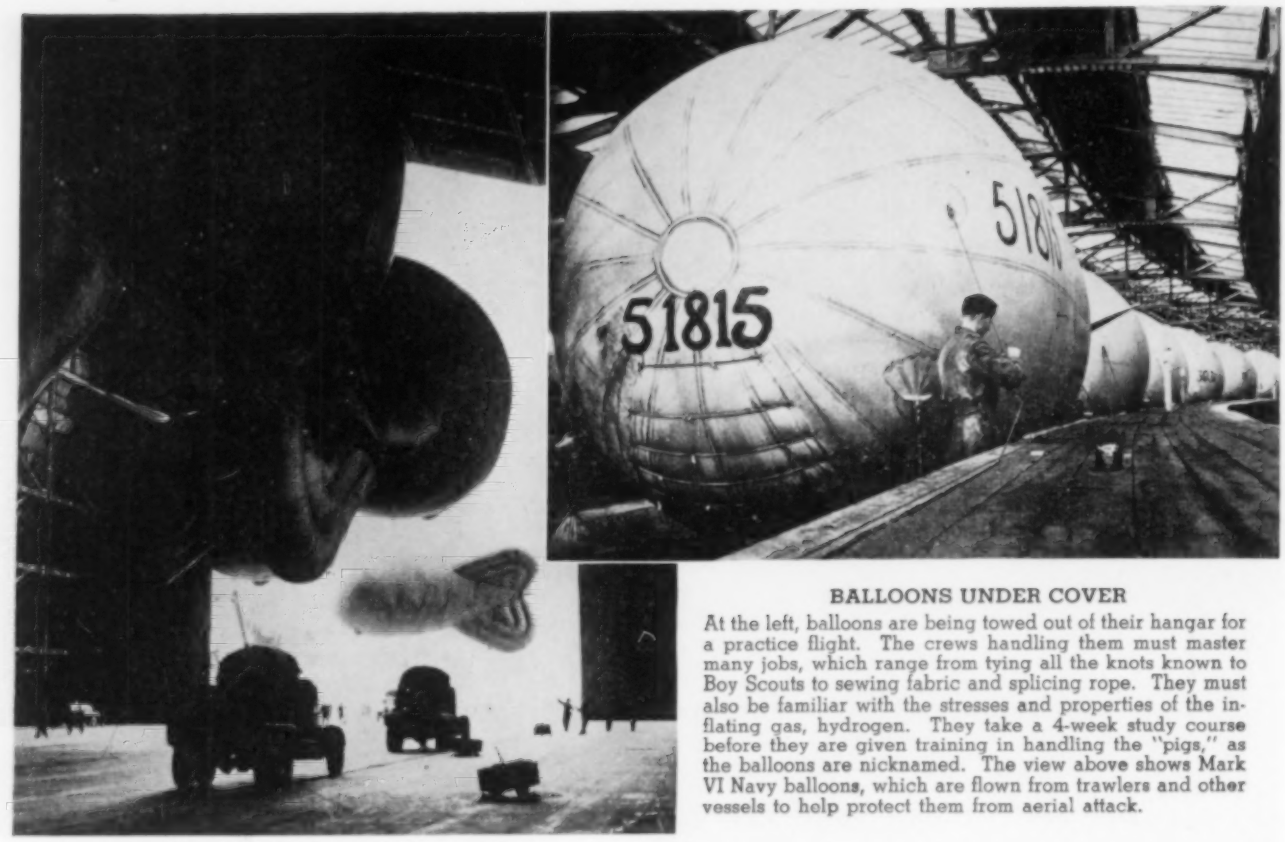
COMPLETE information regarding the balloon barrages that have served importantly to ward off enemy bombing planes in the British Isles is not yet available, but the British Air Ministry has released some facts concerning the gas supply for them. It is disclosed that during the 57-month period from January 1, 1940, to October 1, 1944, the stupendous volume of nearly 3½ billion cubic feet of gas was produced for use in the balloons.

The present extent of the balloon barrages in Great Britain is still restricted information, but as long ago as 1941 statements were published to the effect that the total length was 700 miles. How many more have been placed in the British Isles since then has not been revealed, but it is known that some were thrown up around various French ports and beaches during the invasion of last June. The gas for them came from Great Britain and is included in the foregoing figures.

A barrage consists of a line of captive balloons anchored at various heights. In some instances, cross cables are strung between each adjacent pair of balloons, and from these connections are hung lighter cables or a wire network. In other cases, wires are suspended from the balloons themselves. Either way, they almost certainly bring down planes that strike them, and it is difficult for raiders to detect them in time to avoid them.

The purpose of a barrage is to keep bombing planes at a considerable height. This not only hinders accurate bombing but also keeps the invaders high enough above the earth so that antiaircraft guns can be used against them to best advantage. Planes flying at low altitudes are hard to hit because the guns cannot be swung around fast enough to follow them. Furthermore, shells then have to be set to explode at short range at which they are dangerous to persons on the ground.

As experience was gained, the pattern or arrangement of the balloons was changed to make the barrages more effective. By 1943, the tendency was to place them at three different elevations: high, low, and very low. The bags varied in length from 30 to 120 feet, the smaller ones being used at low altitudes and the size increasing with height. The diameter was approximately one-third the length. Balloons of two general types of construction were then being used, the "dilatable" and the "ballonet." The former consisted of a single cell, with an envelope having four or more lobes into which the gas flowed upon expanding with decreasing atmospheric pressure as the balloon ascended. The ballonet was made up of separate chambers for air and gas with a diaphragm between them. As it rose, the gas expanded and forced the air out of its receptacle. The tethering cable of a gas bag is wound on a power winch to permit raising or lowering it as desired. The winch, in turn, is mounted on a truck and operated by a



BALLOONS UNDER COVER

At the left, balloons are being towed out of their hangar for a practice flight. The crews handling them must master many jobs, which range from tying all the knots known to Boy Scouts to sewing fabric and splicing rope. They must also be familiar with the stresses and properties of the inflating gas, hydrogen. They take a 4-week study course before they are given training in handling the "pigs," as the balloons are nicknamed. The view above shows Mark VI Navy balloons, which are flown from trawlers and other vessels to help protect them from aerial attack.

power take-off from the truck engine. When the wind changes, the truck maneuvers the balloon accordingly by driving to a new location.

So far as information lately released discloses, the balloons used in or supplied by Great Britain have been inflated with hydrogen gas, although some helium may have been exported from the United States for that purpose in recent months. As hydrogen is very inflammable, balloon mortality from incendiary bullets must have been high. They are also known to have been set on fire by lightning. An American, who was in England during the early part of the war, reports that he witnessed the destruction of twenty during one thunderstorm. However, despite their shortcomings, they seem to have been one of the most effective antiaircraft weapons available, and the British had no choice but to replace them when they were destroyed. These replacements probably account for a large percentage of the gas consumption, although losses sustained through leakage also demand continuous production.

The following facts concerning the manufacture of an ample supply of hydrogen for the maintenance of the barrages was obtained from an article published by *The Engineer*, a leading British technical magazine: When the war broke out, there were comparatively few hydrogen-producing plants in England, and most of those were in the northern part of the country. Consequently, the first gas was largely obtained from them. It was compressed, charged into steel cylinders, and transported by truck or railroad to the balloons, most of which were in the London area. As bombing attacks increased and the barrage was extended, the demand for hydrogen exceeded the facilities for transporting it over long distances, and it even became necessary at times to fly the balloons with some coal gas and hydrogen.

This situation led to the establishment of additional hydrogen plants. Most of these were located near the points of greatest barrage concentration, principally in southeastern England, and were well dispersed to reduce the risk of damage by enemy activity. To plan and construct these facilities, a Directorate of Hydrogen Production was formed within the Air Ministry. It enlisted the coöperation of the gas industry, with the result that hydrogen-producing plants were built at many gasworks, while other independent plants of smaller size were situated near the barrage areas.

The final plans adopted called for an expansion of the facilities to insure an output of 40 million cubic feet of hydrogen a week, after allowing for a certain percentage of nonproduction attributable to plants that would probably be put out of commission by enemy action. Of the total volume, the gasworks were asked to furnish 25 million cubic feet. The first of the new gasworks plants were put in operation in September, 1940, and others at regular intervals thereafter until the middle of 1942. As it turned out, bombing never reached the proportions that had been envisioned, except in the southern and eastern parts of England. Consequently, barrage protection in the northern and western areas was gradually transferred to the sections of greatest bombing concentration.

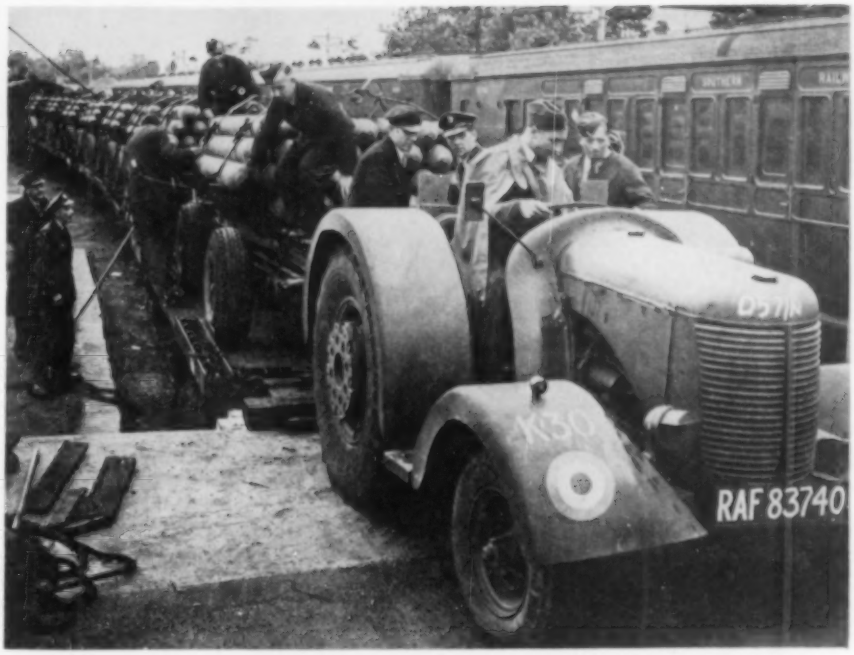
In time, more and more of the hydrogen-production load was taken over by the gas industry. Whereas it had supplied only 43 million cubic feet in 1940, as compared with 545 million cubic feet from other sources, the figures for 1943 showed an output of 541 million cubic feet for the gasworks and of 265 million cubic feet from all other sources. Of the total 3½ billion cubic feet made up to October 1, 1944, the gasworks accounted for 1773 million cubic feet and other sources for 1719 million cubic feet.

The invasion of France and the advent of the flying bomb over England both called for sharp increases in hydrogen production, but fortunately these periods did not coincide. Most of the gas for the barrages placed over French beaches and ports of debarkation came from two plants on the south coast of England, but others also were called upon to contribute. When the flying bomb made its appearance, an additional 500-balloon barrage had to be set up in a hurry, and this necessitated operating all the factories in the London area at maximum capacity. Over a period of ten weeks

the hydrogen consumption amounted to 179 million cubic feet, of which the gas industry furnished 140 million cubic feet. During one week two plants in the London area produced two and a half times their rated capacity, while several others doubled their normal ratings. Subsequently, the 500 balloons in this special flying-bomb barrage grew to 2000.

Most of the hydrogen for the balloons is manufactured by what is known as the steam-iron process. This consists of passing water gas and steam, alternately, through a bed of magnetite iron ore that is maintained at a temperature of from 1650 to 1920°F. A double reaction takes place between the water gas and the iron ore, and in both instances the latter is reduced from Fe_3O_4 to the simple oxide FeO. There is some further reduction to metallic iron where the gas first comes in contact with the ore. The gaseous products of the reactions are burned with added air in a recuperator to provide the heat necessary for the process.

After a few minutes, the flow of water gas is shut off and steam is introduced. This reacts with the iron oxide to reform Fe_3O_4 and hydrogen. The entire cycle takes about ten minutes. Neither of the reactions is complete, and the hydrogen contains an appreciable quantity of undecomposed steam, together with some hydrogen sulphide and carbon dioxide derived from the water gas. These are removed by passing the hydrogen through two purification processes. It then goes to a main storage holder. The iron ore used is a specially calcined product which has both high porosity and resistance to disintegration under the alternate oxidation and reduction to which it is subjected.



A TRAINLOAD OF HYDROGEN

Trucks laden with cylinders of highly compressed hydrogen about to be unloaded from the flat cars that transported them to southern England for use in barrage balloons during last year's flying-bomb attack. During the early part of the war, most of the hydrogen was manufactured in northern England, but plant facilities were subsequently centered nearer the areas of greatest bombing.

The purified gas is withdrawn from the storage holder for compression. Either 4- or 6-stage compressors are generally employed, and the final pressure is 3000 pounds per square inch. The gas delivered by the compressors is charged into steel cylinders arranged on trucks that haul them to and from the balloon sites. During the charging procedure the cylinders and truck are carefully grounded to prevent static electricity, caused by the flow of the gas, from building up potential and possibly creating a spark. The cylinders are periodically pressure-tested and are also examined inside for evidences of corrosion. For the latter purpose there has been developed a special instrument called an Introscope—a telescopic periscope that is inserted in the cylinder and illuminated by a light and a series of prisms.

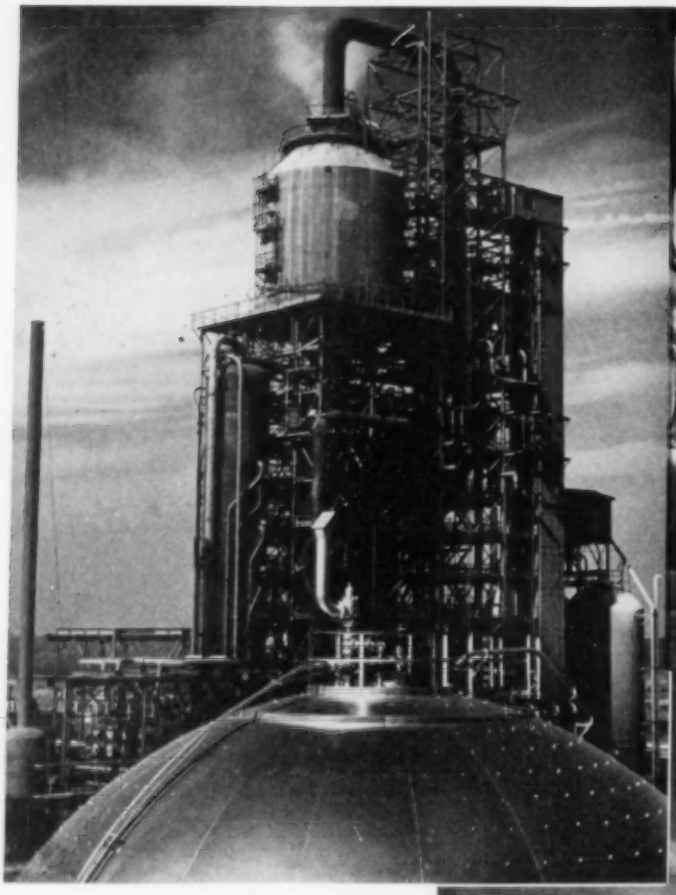
Detachments of the Royal Air Force are posted at all the hydrogen plants to help direct the operations. The managements and personnel of the gas companies and of the specially provided plants that have been engaged in hydrogen production were complimented for their efforts in a speech made a few months ago by Com. P. L. Lincoln of the Balloon Command. He stated that there has never been a shortage of hydrogen, not even at times of sudden heavy demand such as when barrages had to be set up on the Continent during the invasion and in England after the first assaults by flying bombs.

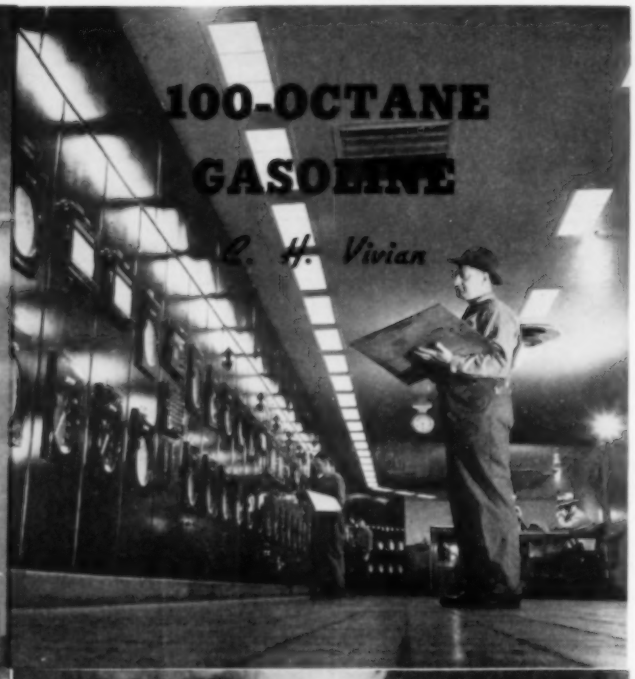
SCRAP IRON FROM BOMBS

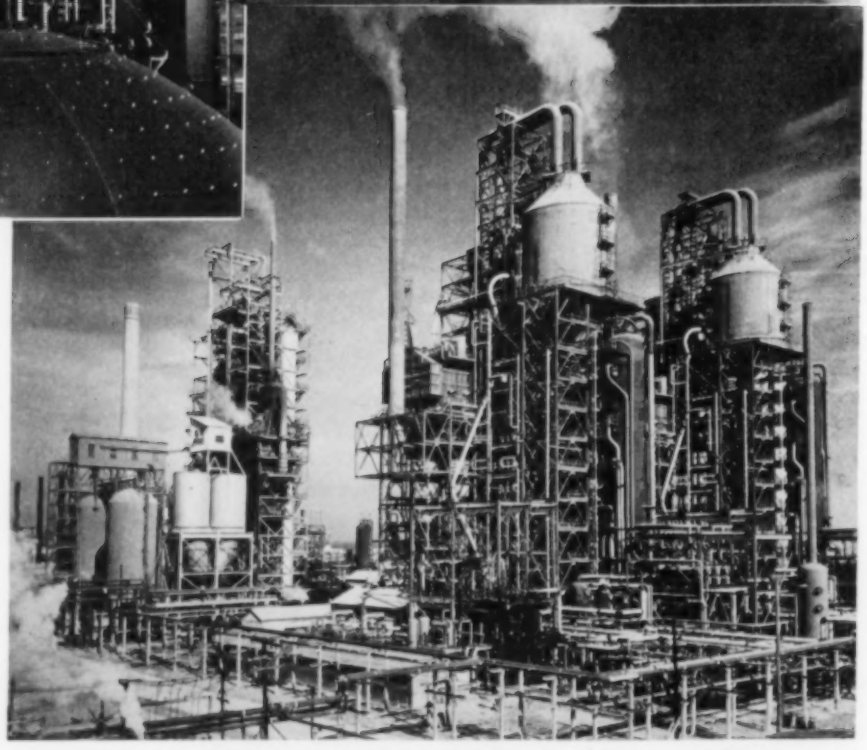
Members of the R.A.F. Balloon Defense gathering up the wreckage of flying bombs brought down by a barrage.

100-OCTANE GASOLINE

L. H. Vivian







FLUID CATALYTIC-CRACKING PLANTS

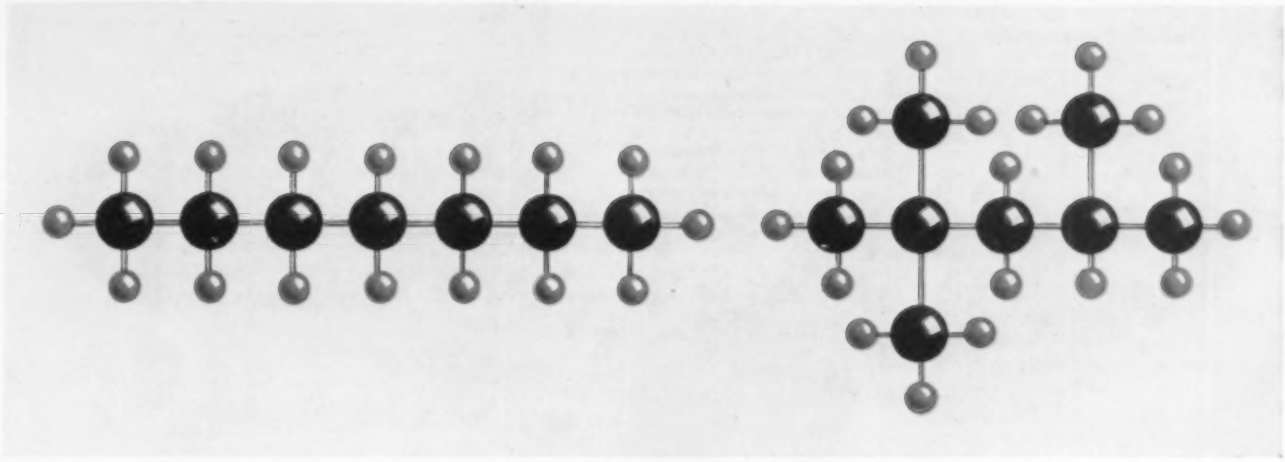
At the left, the upper part of a "Cat" cracker is viewed over the top of a spheroid tank. The colored picture shows the control room of a fluid-catalyst plant, where brilliantly lighted gauges record the temperature and flow of oil, catalyst, compressed air, and steam. In the illustration at the bottom are three Fluid Catalytic-Cracking units at the Baton Rouge refinery of the Standard Oil Company of Louisiana. The one at the left was the first one erected anywhere, having been put "on stream" in May, 1942.

TWO or three generations from now, when World War II can be viewed in the dispassionate perspective permitted by a lapse of time, historians will give various reasons for the failure of the German Reich in its bid for world domination. The explanation will, perforce, cover a lot of ground, for warfare has become a very complex affair. But somewhere in the account there is bound to be mention of 100-octane gasoline and the part it played in upsetting Hitler's well-laid plans. By that time everybody will be familiar with 100-octane gasoline, for they will be using it (or an even higher-grade fuel) in their automobiles and perhaps also in their helicopters.

Even at this close time range we can appraise, in some measure, the invaluable assistance this power-packed fuel has rendered the United Nations. Winston Churchill aptly summarized the matter when he referred to the conflict as "a war of engines and octanes." The Germans realize the significance of 100-octane gasoline even more keenly than we do, and it must be galling to them, in view of their highly developed technology, to have to face the fact that here is a case where they have been outsmarted at their own game.

Germany entered the war with an air armada larger than the combined air forces of her adversaries. Primed for the kill, her confident Luftwaffe in 1940 unleashed a bombing attack on England that was calculated to smash the British into early submission. Britain not only survived the ordeal but inflicted such telling damage on the aerial invaders that Germany had to alter her entire military strategy. Instead of realizing her dream of delivering a quick knockout blow, she was compelled to accept a long war that is inexorably leading to her defeat.

The world knows that British courage never flagged during those dark days of 1940, and no one would withhold one whit of credit from the valorous Royal Air Force flyers who proved themselves masters of their foes in the bitter dog-



THE SECRET OF THE POWER IS IN THE ARRANGEMENT OF THE ATOMS

Ordinary gasoline is made up of hundreds of hydrocarbons differing in molecular construction. In general, the straight-chain-type molecules produce "knock" in an engine, while the branched-chain or ring-type molecules do not. In the diagrams above, the black spheres represent carbon atoms and the red spheres hydrogen atoms. The skinny chain at the left is a molecule of normal heptane (C_7H_{16}) which knocks under almost any condition and, consequently, makes a very poor gasoline component. Pictured beside it is a molecule of iso-octane (C_8H_{18}) which, although it differs but little from normal heptane in the number of its carbon and hydrogen atoms, produces no knock. The way the atoms are arranged makes all the difference. In the octane scale, iso-octane is rated at 100 and normal heptane at 0. In making 100-octane gasoline, alkylate, which is high in iso-octane content, is added to base stock and produces gasoline of around 90-octane rating, which is then increased to the 100-octane level with 3 or 4 cubic centimeters of tetraethyl lead. The base stock must be relatively high in octane rating, and only limited quantities of it can be obtained by ordinary distillation of petroleum. However, catalytic-cracking furnishes a means of producing large amounts of it from various types of charging stock ranging from what is known as reduced crude to light gas oil. More than 75 catalytic-cracking plants are now in service.

fights over London. But the stout-hearted pilots had an inanimate ally that extended a strong helping hand when it was sorely needed. This was 100-octane gasoline. With it powering their high-compression engines, they outmaneuvered and outsped the German planes that were energized by slower-acting 87-octane fuel. Supergasoline was in this case the sling with which David beat Goliath.

From that time on to the present, 100-octane gasoline has given the United Nations an incalculable advantage over the Axis powers. Because of it our planes can fly farther and higher, carry more, climb faster, and take off in a shorter distance than can enemy aircraft. A bomber using 100-octane fuel can, when attacking a target 1000 miles away, carry five more 1000-pound bombs than one using 87-octane gasoline. Greater power is obtained from the same weight of engine, and this, in turn, permits the installation of additional guns and heavier armor, as well as operating from smaller fields.

On the humanitarian side of war 100-octane gasoline has been equally important. Speaking last May, Undersecretary of War Robert P. Patterson said: "Our 100-octane gasoline has meant the difference between life and death or being permanently crippled to thousands of American soldiers. The U.S. Air Force carried back to hospitals 18,000 sick and wounded from the African theater. They ferried 17,000 more from the New Guinea jungles to Port Moresby. Had the planes used lower octane fuel, 30 percent of these men could not have been moved."

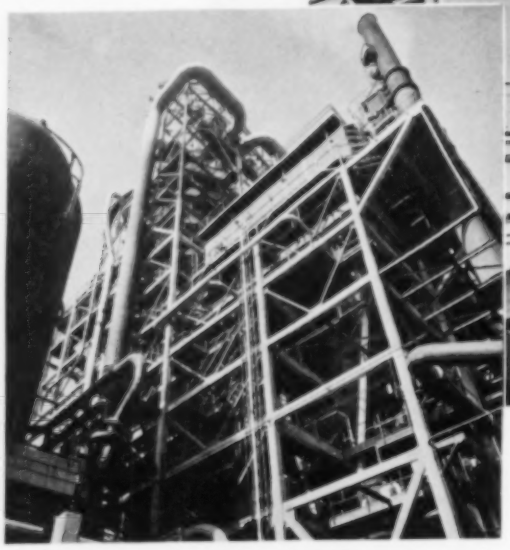
A modern airplane engine that develops 2200 hp. with 100-octane gasoline is no larger than the 525-hp. engine of 1927. Engine designers have been able to cram more power into the same space by increasing the compression ratio in the cylinders. They could not have done this, however, if the higher-grade fuel had not been available. Lower-grade gasoline produces a "ping" or knock with which all motorists are familiar. In an automobile engine it is primarily a source of annoyance, but in an airplane engine it can be disastrous. An engine knocks when the fuel burns too fast for the speed of the piston, and the "pinging" noise is the audible expression of a sudden explosion. Conversely, if the fuel burns slowly and progressively, it exerts a steadier and more effective push on the piston and there is no knock. The tendency of a given gasoline to produce knock grows as the compression ratio increases. However, more power can be obtained by using a higher compression ratio, so the importance of having the proper fuel is obvious.

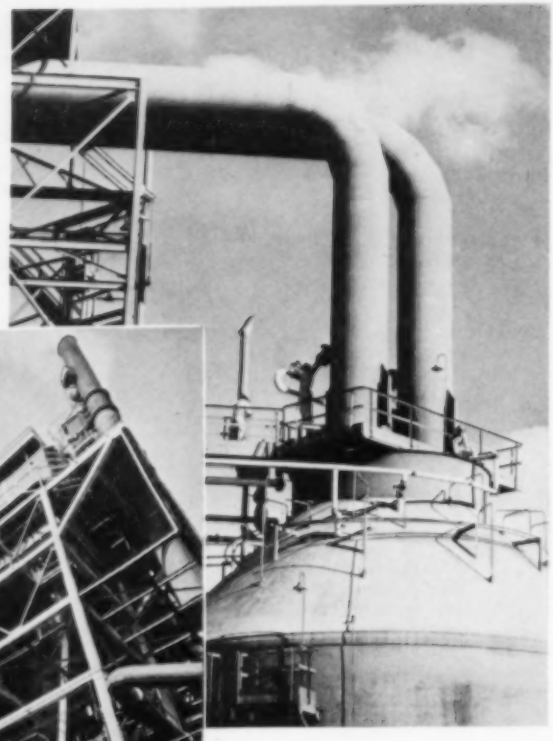
One of the first investigators of knocking was Harry Ricardo, designer of the L-head engine that is used by various manufacturers. Before the true nature of knocking was known, the opinion prevailed that it was caused by premature ignition, and the accepted method of reducing it was to retard the spark. It is said that Ricardo's work on the problem was inspired in 1905 by Prof. Bertram Hopkinson, one of his teachers at Cambridge University, England, when he expressed the belief that knocking might be attributable to an explosion wave in the burning gases. Following his graduation, Ricardo began experimenting with various designs of engines and became convinced that knocking was occasioned by the detonation of a small part of the fuel mixture. He tried different fuel compositions and discovered that knocking could be eliminated by using certain aromatic hydrocarbons that were at that time obtained from coal tar.

Technologists of American automobile and oil-refining concerns began trying more than a quarter-century ago to find a practical way of producing a motor fuel of low knock characteristics. After they had added literally thousands of substances to gasoline in the hope of discovering one that would improve it, the late Thomas Midgley, Jr., of General Motors Company, resorted to tetraethyl lead in 1921, and it worked. Dr. C. A. Kraus, professor of chemistry at Clark University, Worcester, Mass., developed a commercial method of manufacturing this obscure, heavy, water-clear liquid, and in 1924 the Standard Oil Company of New Jersey and General Motors Corporation formed the Ethyl Gasoline Corporation to market it. Ever since then it has been used to fortify gasoline in making the premium motor fuel that is familiar to all car owners. Very little Ethyl gasoline is now going to the public

OF IMPOSING SIZE

A Fluid Catalytic-Cracking unit is a huge and intricate assembly of towers, tanks, piping, and supporting steelwork. The 15,500-barrel-per-day (charging-stock) size that has been built oftenest thus far rises more than 200 feet in the air, requires about three million pounds of structural steel, and costs around $5,000,000. Approximately 400,000 feet of pipe and 200,000 pounds of welding rod are used in its construction. The heat exchangers and coolers contain 328,000 feet of tubing. The regenerator is 42½ feet in diameter and 35 feet high and the reactor is 23 feet in diameter and 47 feet high. In the right-hand view, which shows the top of a regenerator, the men appear as pygmies. Each of the twin pipes where it leaves the vessel is 42 inches in diameter. At some locations, 72-inch pipe is used.





because most of the available tetraethyl lead is serving as a component in aviation gasoline.

Midgley found that the addition of small amounts of tetraethyl lead to each gallon of gasoline materially increased its antiknock quality, but 100-octane fuel was still a long way off. In fact, the octane scale that is now used as a convenient standard of measurement was not devised until five years after Midgley's discovery. Virtually all the gasoline made at that time was what is known as straight-run, which means that it was produced simply by distilling crude oil by heat alone. By that process the lightest petroleum components, those that have the lowest boiling points, are vaporized first and are followed progressively by the heavier ones as the heat is stepped up. The gasoline yield consists of only those hydrocarbons within the gasoline range that are present in that form in the petroleum. There is a great variation in their content in different crude stocks, and straight-run gasoline ranges in antiknock or octane rating all the way from 2 to 60, with most of them running between 40 and 60. Such gasoline is suitable only for low-compression, low-efficiency engines, and even the addition of tetraethyl lead leaves it far below the standard required for modern airplane engines.

But by selecting crude oils that are especially rich in the gasoline hydrocarbons having high antiknock qualities, a straight-run fuel can be distilled that has an octane rating of about 75. A thimbleful or so of tetraethyl lead per gallon will increase this to the 87-91 octane range. This is the highest antiknock level that can be obtained commercially with a straight-run gasoline, and the quantity that can be produced is limited because only a small percentage of the total crude oil available will yield the rich antiknock base stock that is needed

However, the advent of the so-called "87" gasoline was a boon to engine designers, and they were quick to take advantage of the opportunity it gave them to increase compression ratios. Compared with the 60-octane product that had previously been used in airplane engines, the new fuel delivered 33 percent more power for the same engine weight. Meanwhile, petroleum technologists tackled the knotty problem of finding a way to provide a base stock of an even higher antiknock rating, for they knew that such a fluid, plus tetraethyl lead, would yield a fuel exceeding even the "87" gasoline in power-producing value.

At this stage was discovered a method by which 100-octane gasoline could be made on a laboratory scale. Dr. Graham Edgar, working in the Yonkers, N. Y., laboratory of the Ethyl Gasoline Corporation, had previously ascertained that one of the hydrocarbons in gasoline would operate the highest compression engines of that time (1926) without knocking. The hydrocarbon was trimethyl pentane, better known as iso-octane. The first result of the discovery was the establishment of the octane scale which, with slight modifications, is the standard of measurement now used in testing gasolines. Doctor Edgar assigned a value of 100 to the knockless iso-octane and one of 0 to another gasoline hydrocarbon—normal heptane—which knocks under almost any condition. Using the resultant scale, a gasoline with a knock equivalent to that of a mixture of 80 percent iso-octane and 20 percent normal heptane is given an octane number of 80. The tests are made in a standard single-cylinder engine, and the knock is recorded by instruments. At about the same time, or perhaps even earlier, Ricardo was using a reference fuel made up of toluene and heptane, and the octane number replaced what he called the toluene number.

Since iso-octane was, in effect, 100-octane gasoline, it might be supposed that its discovery solved the problem. It did not, however, for two reasons: first, iso-octane does not vaporize well and, consequently, could not be used satisfactorily by itself in a conventional engine; and, second, the cost of producing iso-octane by the methods then known was around $20 a gallon. Experiments revealed, though, that the octane rating of a 75-octane base-stock gasoline could be raised to such a level by iso-octane that the further addition of tetraethyl lead would increase the octane rating of the final product to 100. The way pointing to commercial quantities of 100-octane gasoline was in view, but there were certain obstacles to be surmounted. It was still necessary to find practical processes for the production of adequate quantities of high-grade base stock and also substantial supplies of iso-octane at a cost of a few cents a gallon. Admittedly, these were not easy hurdles to clear, but through the alchemy of modern chemical engineering the goal has been reached.

The iso-octane problem was the first one solved, but the solution came gradually rather than percipitately. Gasoline is made up of hundreds of hydrocarbons that are classified in the paraffin, olefin, aromatic, and naphthene series. Each

hydrocarbon has its own velocity of combustion and, consequently, its own knocking or antiknocking characteristics. Each also has its distinctive molecular arrangement. Fortunately, this can be upset, so it is possible through various means to dismember the molecules of one hydrocarbon and to reform them into molecules of another and more desirable one. Sometimes large molecules are broken down and made to reassemble themselves into smaller ones. In other cases the procedure is reversed, and in still others the size of the molecules is changed only slightly, if at all, but the atoms are rearranged.

This amenability of hydrocarbons to transformation is the basis of low-cost, quantitative iso-octane production. By the first method employed, two molecules of isobutylene—a gas obtained in refineries and theretofore largely wasted—were combined by polymerization into di-isobutylene, a colorless liquid. This was accomplished by subjecting isobutylene to heat and pressure and passing it over a phosphoric-acid catalyst. Then, by hydrogenation—again utilizing heat, pressure, and a catalyst—two atoms of hydrogen were forced into each molecule of di-isobutylene to form iso-octane. By 1929 iso-octane was being sold by one producer for $7.40 a gallon, but at that price it served chiefly as a standard for determining the octane rating of commercial gasolines. Even then, however, our Army was employing it in relatively small quantities to make 100-octane gasoline for aviation-engine experiments conducted at Wright Field, Dayton, Ohio. Gradually the cost was reduced still further, and a commercial form of iso-octane, known as hydrocodimer, came into limited use as a blending reagent.

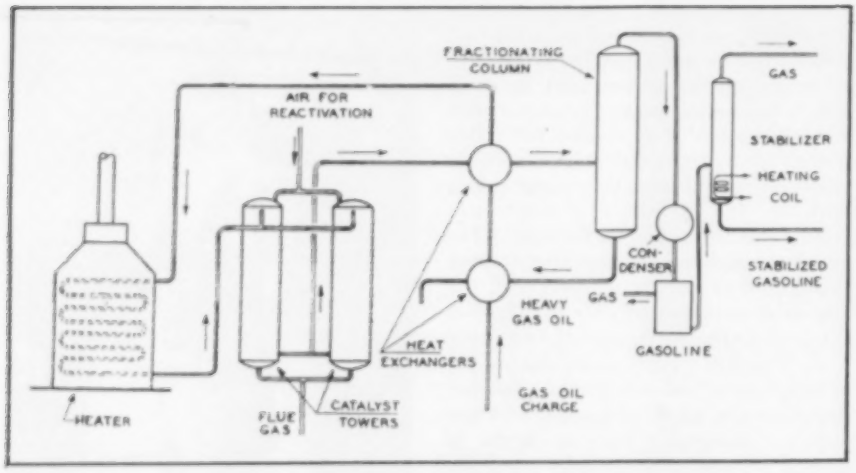
As hydrogenation required the application of pressure of several thousand pounds per square inch, very heavy and expensive equipment had to be provided. Meanwhile, petroleum technologists had continued their quest for a better method of producing iso-octane, and in 1938 pulled the much simpler process called alkylation out of their magical hat. This eliminates hydrogenation and consists essentially in bubbling the refinery gases butylene and isobutane through sulphuric acid or hydrogen fluoride. The product, which is known as alkylate and averages 90 or more in octane rating, was first made commercially by the Humble Oil & Refining Company at Baytown, Tex. There is a fairly abundant supply of butylene in refineries, but isobutane, the other raw material needed, is rather scarce. However, there is plenty of normal butane, which differs from isobutane only in the arrangement of the atoms within the molecule. So the technologists delved into their hat again and brought out the process known as isomerization by which they could rearrange the atoms to form the desired product. This is accomplished by bringing normal butane in contact with aluminum chloride in the presence of hydrochloric acid. The first commercial isomerization plant was opened in March, 1940, at Palembang, Netherlands East Indies, by an affiliate of the Standard Oil Company of New Jersey and was destroyed two years later to prevent it from falling into the hands of the Japanese.

This, then, was the general status of the 100-octane-gasoline industry at the time of the Pearl Harbor attack. The nation's refineries were turning out about 49,000 barrels of the superfuel daily. As we prepared for active warfare, the President called for 60,000 military airplanes annually, and this precipitated an immediate and vast increase in our 100-octane-gasoline output. We had to think not only of our own huge potential air force but also of the rapidly growing air fleets of our Allies. Tetraethyl-lead and iso-octane manufacturing techniques were on a sound basis, and facilities for supplying them could be readily expanded. With regard to base-stock gasoline, however, the situation was not so favorable. Just about all the selected crudes that could be gathered from the various producing areas were already being utilized to provide the 75-octane straight-run gasoline required for the foundation of the blending process. There was urgent need for further chemical legerdemain, and the technologists were equal to the occasion.

The rabbit that the laboratory magicians pulled out of the hat this time is called catalytic cracking. This is another scheme for juggling the atoms of

A CAPSULE FOR POSTERITY

The first quantity shipment of 100-octane gasoline was made to the U. S. Army Air Corps on April 30, 1934, from the Wood River, Ill., refinery of the Shell Oil Company. In observance of the tenth anniversary of the occasion, the scene pictured above was enacted on the same refinery site. Shell's president, Alexander Fraser (left), is holding a gallon of the original gasoline in one hand and in the other a copy of the contract under which the 1934 shipment was made. These were placed in a time capsule and lowered into a monument. Assisting Mr. Fraser were Mrs. James Doolittle, whose husband, Lieutenant General Doolittle, led the first aerial-bombing attack on Tokyo, and Robert P. Patterson, Under-Secretary of War. At the same time, Shell dedicated new twin Fluid Catalytic-Cracking units that are now producing base stock for 15,000 barrels of 100-octane gasoline daily, or enough to send 400 bombers on the longest missions over Europe every 24 hours. The ceremonies at Wood River were held on the opening day of "100-Octane Week," sponsored by the oil industry to bring to the nation's attention the service it has rendered in supplying United Nations fliers with great quantities of gasoline that is superior to any our enemies can make.



FLOW DIAGRAM OF HOUDRY PROCESS

E. J. Houdry devised the original catalytic-cracking process in France some twenty years ago. It was developed to the commercial stage by American oil refiners and was the source of most of the base stock for the 100-octane gasoline made during the early war years.

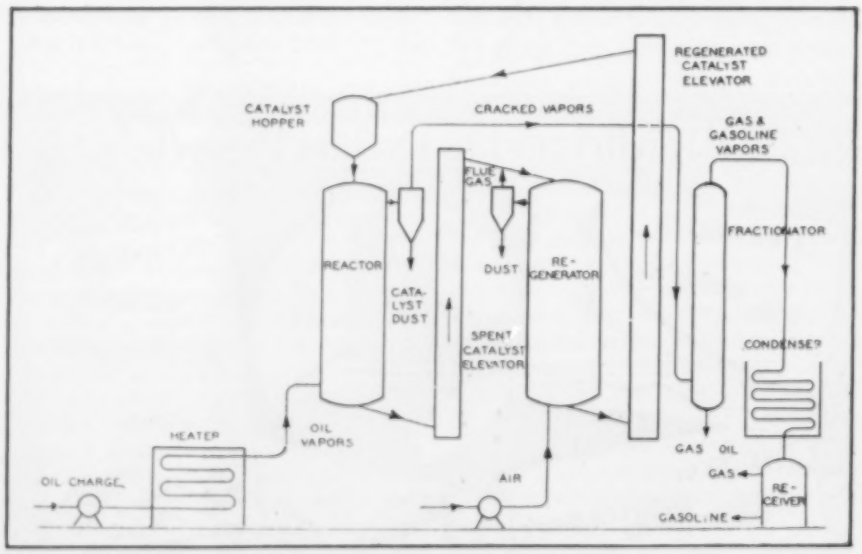
hydrocarbon molecules so as to convert unwanted types into wanted ones. It goes a step farther than thermal cracking, which has been in use for 30-odd years. Thermal cracking utilizes heat and pressure to break down heavy hydrocarbon molecules and to reform some of them into lighter ones in the gasoline range. It makes it possible to produce around 44 barrels of gasoline from every 100 barrels of crude oil, as compared with twenty barrels by ordinary distillation. Such gasoline is not, however, a wholly satisfactory base stock for aviation fuel partly because it is not sufficiently susceptible to treatment with tetraethyl lead to raise its octane number to the desired level. On the other hand, catalytically cracked gasoline is an 81-octane fuel that responds admirably to blending with alkylate and permits of further enrichment with tetraethyl lead.

Back in 1913, A. M. McAfee developed a method whereby anhydrous aluminum chloride could be used as a catalyst for cracking, but nothing of practical importance came of it. The discovery that a suitable catalyst would improve the cracking reaction was made by E. J. Houdry in France in the 1920's, although it did not reach a commercial scale until some years later. The process was eventually adopted and exploited in this country by the Sun Oil Company and the Socony-Vacuum Oil Company, and the latter erected the first commercial plant in 1936 at Paulsboro, N. J. By this method the charging stock is vaporized and passed through a fixed bed of catalytic material which at first was a natural clay but now is generally a synthetic silica-alumina compound. The catalyst not only accelerates the cracking reaction but also directs its course so as to increase the yields of the desired products. Passage of the oil vapors through the catalyst coats the latter with coke, and it becomes necessary after a short period of operation to regenerate it by burning off the deposit with a stream of compressed air supplied by a compressor driven by a gas turbine. Cracking is continued meanwhile by transferring the stream of oil vapor to another reactor.

The Houdry Process was the only catalytic cracking process available before the Pearl Harbor attack, and plants using it turned out most of the base stock for 100-octane gasoline during the early part of the war. By 1943 there were 26 Houdry units in operation in this country, most of them having been engineered and built by E. B. Badger & Sons Company. They had a combined daily capacity for the processing of more than 300,000 barrels of charging stock. The yield of aviation-gasoline base stock varied from 25 to 50 percent of the input, depending upon the type of charging stock employed and the extent of the recycling.

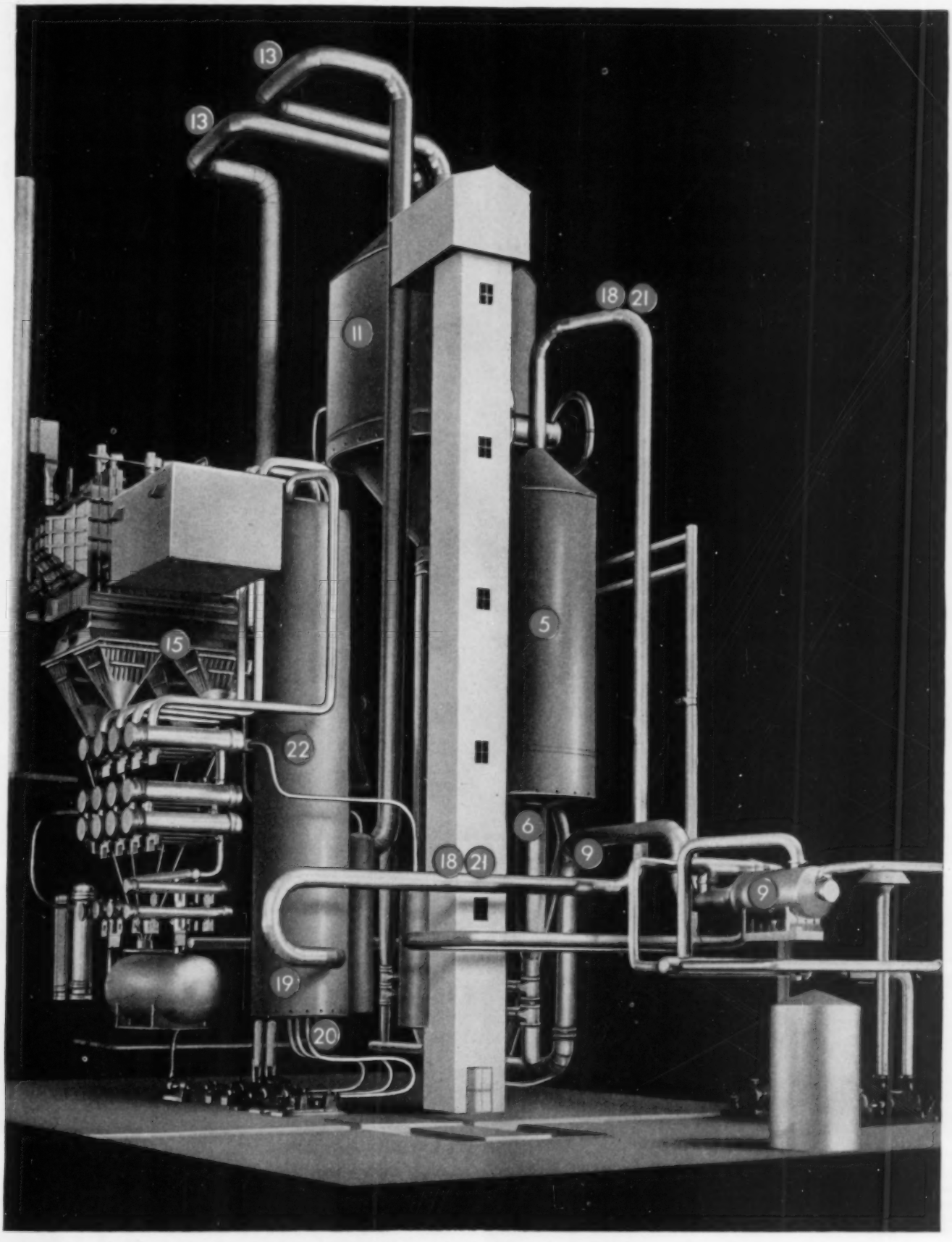
Anyone who has read this far need hardly be told that the oil-refining industry is anything but a static business, that it is characterized by a continual change in methods, and that each succeeding change usually represents a stride forward. It is invariably true that before a plant can be put into operation its ways of doing things have been improved upon. Not infrequently an entirely new process that performs the same work more effectively has been developed. In short, technology moves so fast that the operating departments have difficulty in keeping up with it. Therefore, as soon as catalytic cracking was introduced it was inevitable that the researchers should start pulling it apart to see how it worked and then reconstruct it in an attempt to find better means of accomplishing the desired results.

One group that got busy along these lines was the Standard Oil Development Company, research and development affiliate of the Standard Oil Company (New Jersey), which originated investigations and did most of the subsequent development work from which came the revolutionary Fluid Catalytic-Cracking process. Contributions to the latter were made by the Standard Oil Company of Indiana, The Texas Company, the Universal Oil Products Company, The M. W. Kellogg Company, and the Shell Development Company. The patents were made available to the entire oil industry, with Kellogg and Universal Oil Products acting as licensing agents. Both these organizations design plants,



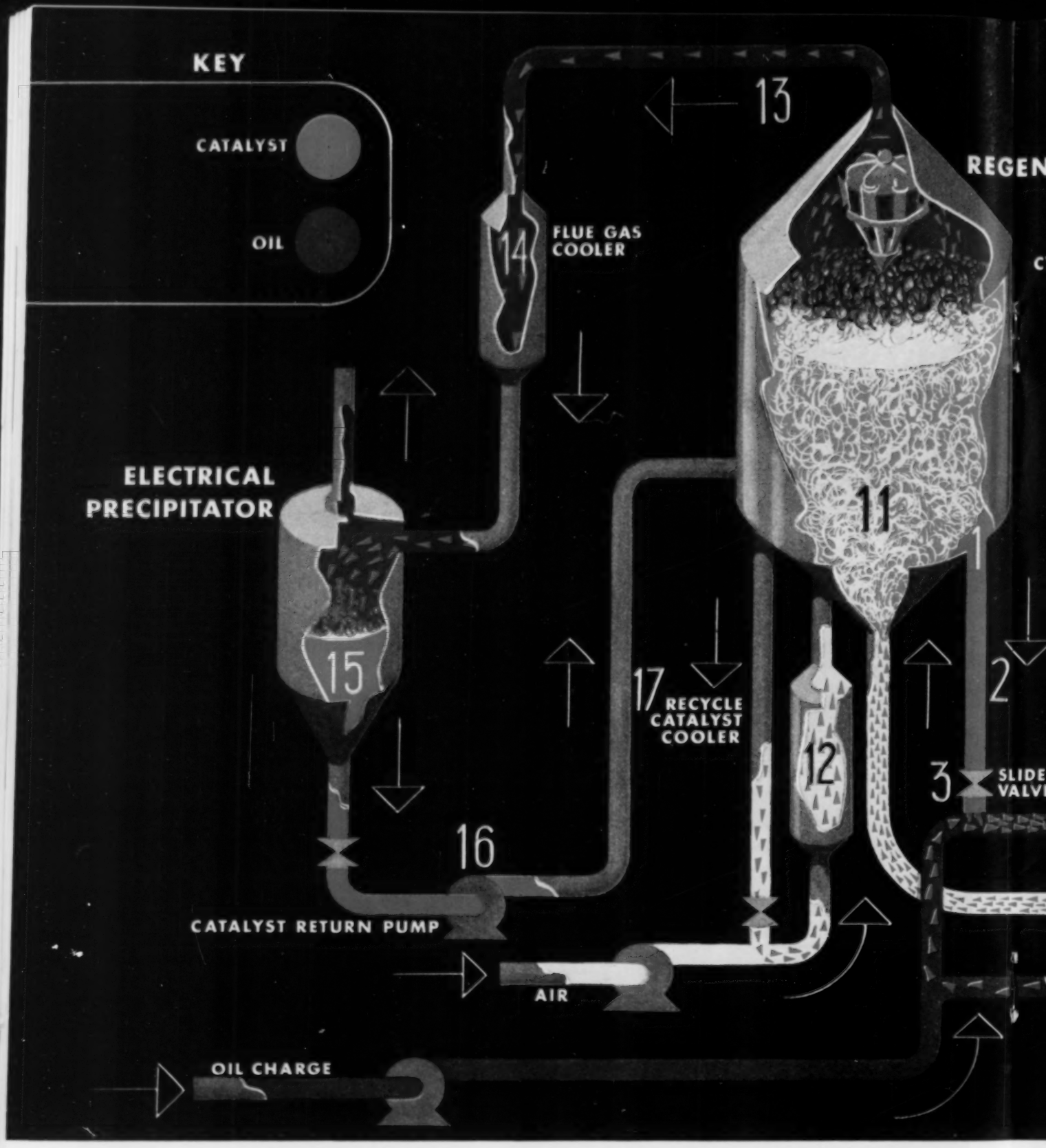
FLOW DIAGRAM OF T.C.C. PROCESS

This process uses a pelleted catalyst that is elevated during stages of the cycle by means of mechanical conveyors. The first full-scale commercial plant was placed in service in 1943, following a 2-year development period. The T.C.C. Process is licensed by the Houdry Process Corporation.



MODEL OF A FLUID "CAT" CRACKER

The operation of a Fluid Catalytic-Cracking unit is traced step by step in a colored flow diagram on the two following pages. On this page and on page 138 are different views of a scale model of a fluid plant. As the numbers on them correspond with those on the flow diagram, it is possible to see what each piece of equipment looks like. The model is displayed in the New York offices of The M. W. Kellogg Company, designers and builders of oil-refining equipment. All the explanatory illustrations are published through the courtesy of the Kellogg organization.



The regenerator is a good place to start our description, because its capacity to remove carbon determines the capacity of the entire unit.

1 **Hot catalyst,** ready for use, is stored in the regenerator and in the

2 **Catalyst Feed Lines or Legs,** down which the catalyst flows to the

3 **Oil Feed Lines,** where the catalyst is injected into the oil stream. The heat of the catalyst vaporizes the oil and, in the

4 **Reactor Feed Lines,** the movement of the catalyst-oil mixture into the reactor is caused by a difference in density between the material in (2) and (4) without the application of any direct mechanical force. The oil and the catalyst flow up two reactor feed lines into the

5 **Reactor,** where the mixture establishes a definite level or bed. The depth of the bed regulates the time of reaction and can be varied for any desired degree of cracking. As the catalyst becomes coated with carbon, it separates from the oil vapors by gravity, aided by cyclone separators at the top of the reactor. The spent catalyst flows through the

6 **Stripping Section** at the bottom of the reactor, where the vapors are released [their further course is traced in numbers (18) to (22)]. From the reactor, the spent catalyst flows downward through the

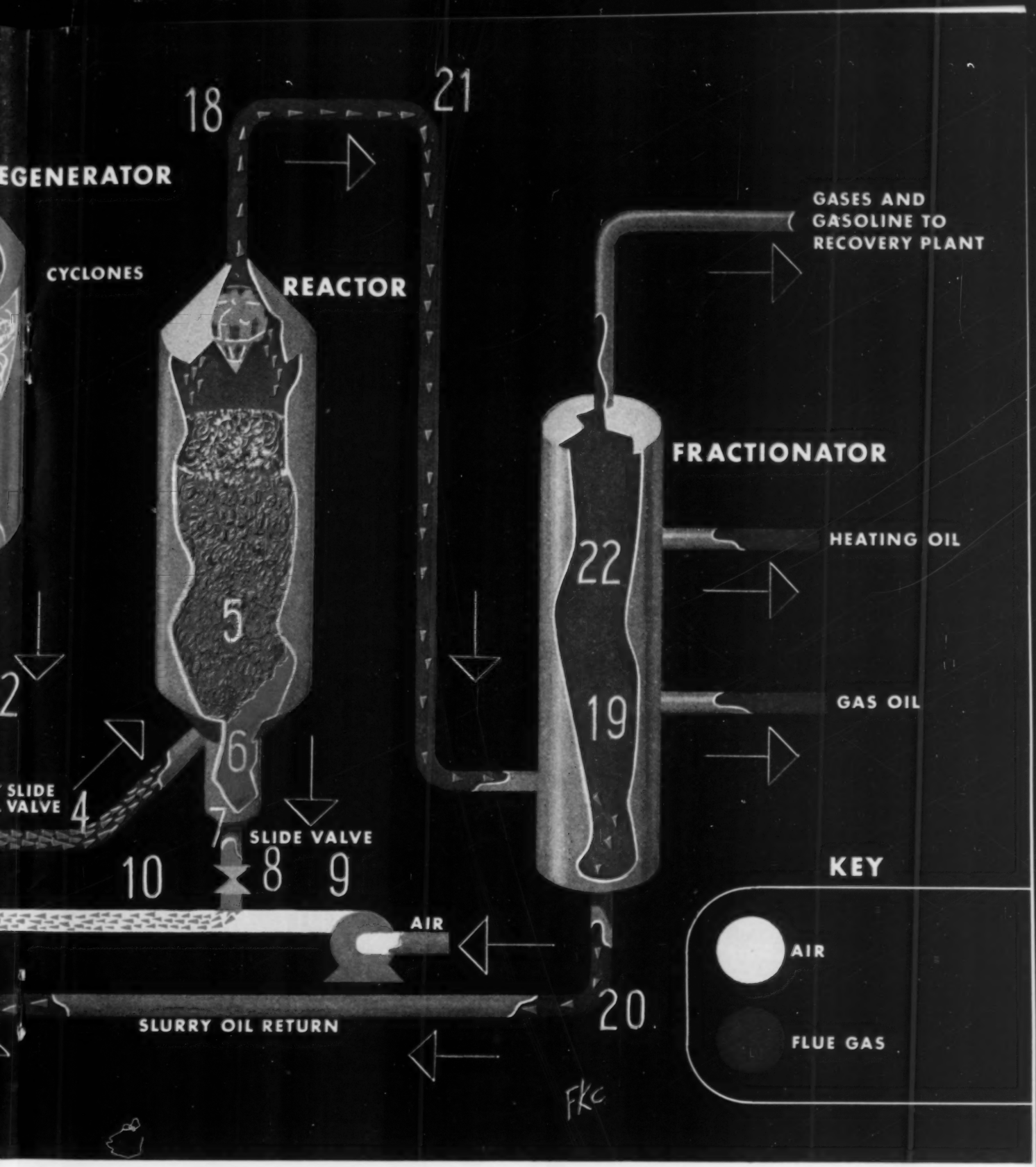
7 **Discharge Line,** where its density is controlled and maintained at about 25 pounds per cubic foot. It is then released through a

8 **Slide Valve,** after which compressed air is admitted from the

9 **Air Supply Line.** This aerates the catalyst to a density of from 2 to 4 pounds per cubic foot and permits it to flow as a fluid through the

10 **Regenerator Return Line.** Thus, again, the material moves without direct mechanical aid, the air serving primarily for aeration, not propulsion. The catalyst flows into he

How the
Catalytic-Cr
Process Op



the Fluid c-Cracking Operates

11 Center Section of the Regenerator, where it again assumes a bed level and where, as in the reactor, the continuous feed of aerated catalyst creates a zone of extreme turbulence. The air introduced at (9) continuously regenerates the catalyst by burning off the carbon. With the aid of cyclone separators, the regenerated catalyst is retained in the regenerator, from which it is constantly withdrawn for reuse. The temperature in the regenerator is governed by the

12 **Recycle Catalyst Cooler,** through which a portion of the catalyst is circulated. The heat here given up by the catalyst is used to make steam. Together with the small amount of catalyst that is carried over with it, the flue gas issuing from the top of the regenerator passes through the

13 **Regenerator Exhaust Line** to the

14 **Flue Gas Cooler,** which also produces steam. It then goes to the

15 **Electrical Precipitator,** where the catalyst is separated from the flue gas. The catalyst next flows down to storage, from which it is refed to the system as desired by the

16 **Catalyst Return Pump** through the

17 **Fresh Catalyst Feed Line.** Catalyst that the cyclones have failed to retain in the reactor is carried with reaction products through the

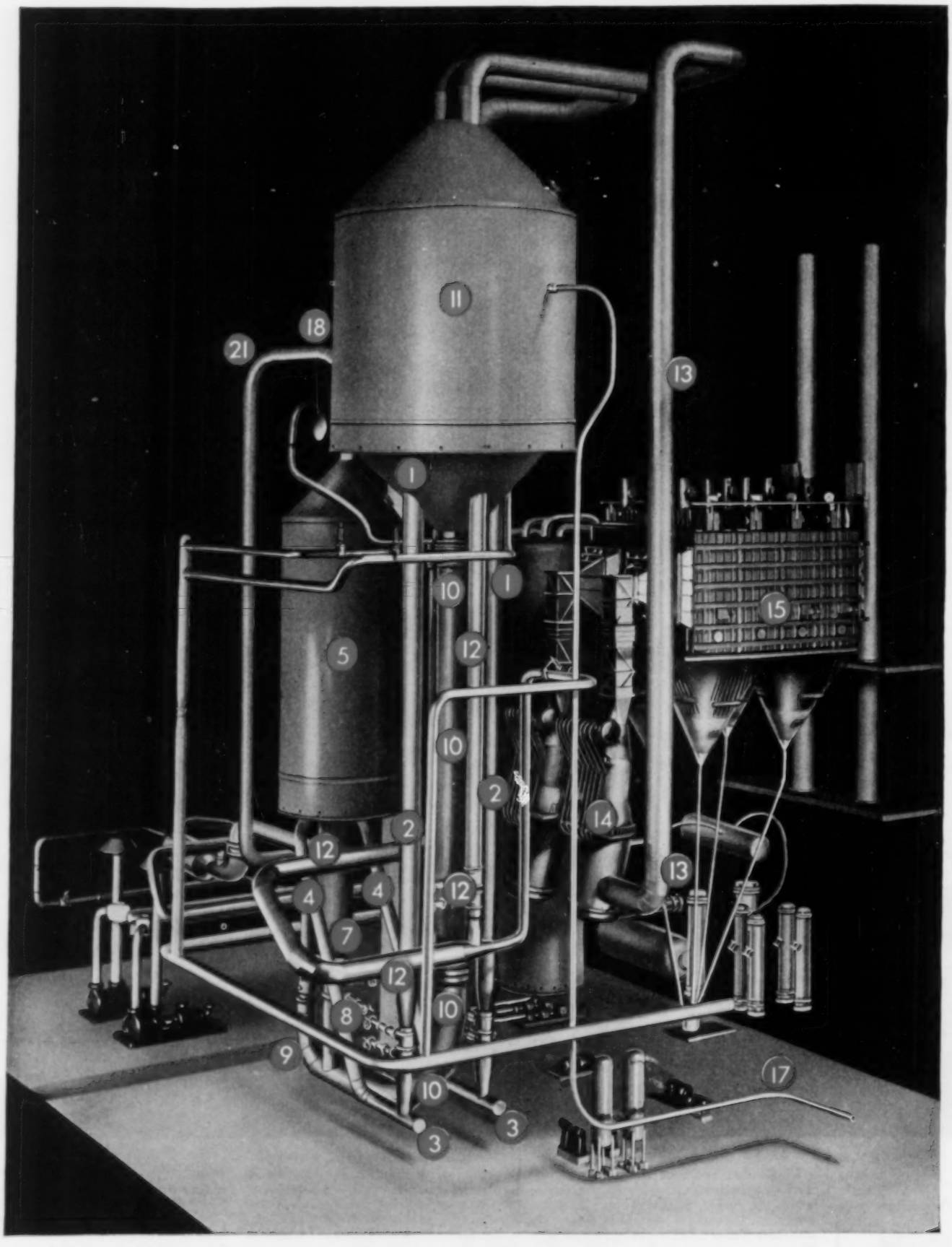
18 **Reactor Overhead Line** to the

19 **Fractionator,** where the catalyst is admixed as a slurry with the heavy oil fraction in the bottom. The slurry is returned through the

20 **Slurry Oil Return** to the fresh-feed oil line and recycled to the reactor. Returning now to the oil vapors, the gases formed by cracking in the reactor are carried by the

21 **Reactor Overhead Line** to the

22 **Fractionator,** where they are separated into 4 fractions: overhead (gases and end-point gasoline), heating oil, gas oil, and catalyst-slurry oil.



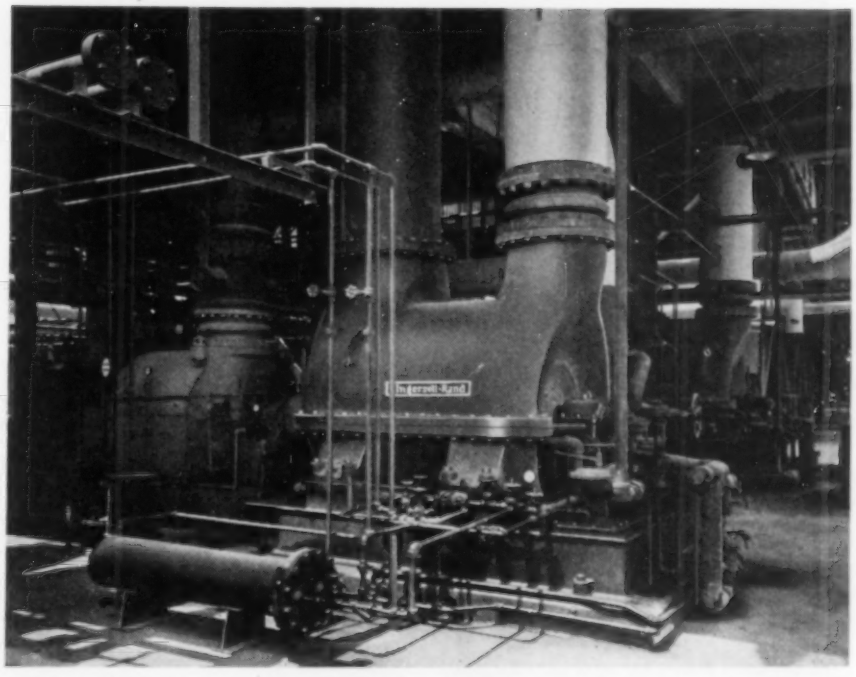
ANOTHER VIEW OF THE MODEL

Supporting structural steelwork has been omitted from both model pictures in order to simplify them. The model is of a unit that can handle 15,500 barrels of charging stock daily, which is the capacity of all the first ones built. Thus far all the plants have been constructed under wartime pressure, and they tend towards height rather than breadth. Future designs will perhaps provide for lower structures, covering more ground and costing less. The turboblowers that furnish vital fluidizing air for the process are at the extreme left.

and the former also constructs them, having accounted for two-thirds of the capacity thus far provided. The process received such immediate acceptance that it now serves half the nation's catalytic-cracking capacity and accounts for two-thirds of the catalytic-cracking capacity built since we entered the war.

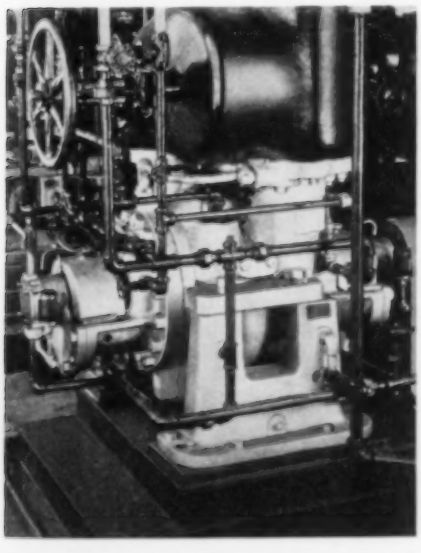
The Standard Oil Development Company workers conceived the idea of employing the catalyst in a finely divided form, and in the fluid method it is a chalk-like powder only slightly coarser than talcum powder. They reasoned, and correctly, that these minute particles would provide a maximum area of contact for the oil vapors. Besides being tiny, each grain of silica-alumina catalyst is porous, and the walls of the pores vastly increase the surface area. It is said that a single pound of a good-grade cracking catalyst of this kind has an exposed area aggregating 50 acres, and it has been computed that the combined surfaces of the particles that pass through one large cracking unit in a day is equal to all the land area in the United States.

Having demonstrated by small-scale experiments that a powdered catalyst would function satisfactorily, the investigators were confronted with the problem of how best to move it through the plant. It was already known that the catalyst and vaporized charging stock would flow into the reactor as a fluid, and this same feature of fluidity was successfully extended to the other side of the cycle—the movement of the catalyst through the regenerating equipment. To do this, the technologists devised a regenerating system in which the catalyst is suspended in a stream of compressed air.



TURBOBLOWERS

In a gaseous medium, powdered catalyst flows like a liquid, and it is this feature of fluidity that gives the Fluid Catalytic-Cracking Process its name. During the reaction part of the cycle the gaseous medium is the vaporized charged oil; elsewhere it is compressed air, normally at 15 pounds pressure. Since great volumes of air are required, centrifugal-type, turbine-driven, multi-stage compressors serve the needs to best advantage. Two machines, each of half the capacity, or one of full capacity, may be employed. Shown here are two Ingersoll-Rand turboblowers that supply air for a cracking unit of the Pan American Refining Corporation, Texas City, Tex., that produces base stock for 1,800,000 gallons of aviation gasoline each week. Each blower is driven by a direct-connected 1750-hp. steam turbine and has a discharge capacity of 22,500 cfm.



SLURRY RETURN PUMP

When the cracked gases from the reactor of a Fluid Catalytic-Cracking unit are separated in the fractionator, the heaviest liquid fractions settle on the bottom, along with some powdered catalyst that is carried over. Together they form a slurry that is pumped back to the reactor for recirculation. The Ingersoll-Rand pump shown here is built for service of this type. The slurry is both hot and abrasive, and special materials and some special design features are embodied in the pumps to counteract its erosive action.

Although the development of the fluid process was compressed into two years, it was a monumental job. The first laboratory tests were conducted on literally a half-pint scale. Hundreds of catalysts and scores of charging stocks were tried out. By the time the first commercial unit was in blueprint form, the endeavors of the Standard Oil Development Company alone had involved some five million man-hours of research and engineering and had cost several million dollars. When the undertaking reached the stage of building a 100-barrel-a-day pilot plant, the staff grew to 100 chemists, chemical engineers, and mechanical engineers, and these worked with several hundred operating men, analysts, and mechanics. At one point in the laboratory investigations a 75-foot-high structure was erected by The M. W. Kellogg Company partially of glass so that the engineers could see and study the operations.

In the Standard Oil Development Company's 100-barrel-a-day pilot plant the catalyst was fed into a stream of vaporized oil by means of a screw conveyor and the mixture was sent to a heated vessel where cracking took place. It was then that further investigations proved the practicality of fluidizing the powdered catalyst with air, oil vapors, or steam so that it would flow like oil or water. This use of the air-lift principle offered the advantages of being able to alter the density of the stream by changing the volume of the vaporous medium and to vary the amount of catalyst in the cracking vessel by raising or lowering the level of the fluidized material. Thus flexibility of operation, that would facilitate handling various types of charging stock, was added to the desirable feature of being able to keep the catalyst circulating with no moving parts in the system. To put the fluid idea into effect, the 100-barrel-a-day pilot plant was completely rebuilt and, after a brief but successful period of operation, plans for a 13,000-barrel-a-day unit were put through without further delay because it was evident by that time that we were heading toward war. This first commercial plant was put in service in May, 1942, by the Standard Oil Company of Louisiana. At the present time 39 units are operating and more are being constructed.

Another outgrowth of the Houdry Process is the Thermofor Catalytic-

CATALYST STORAGE

More than 400 tons of powdered silica-alumina catalyst is continually circulating through a Fluid Catalytic-Cracking unit of the most frequently built size. It moves at the rate of a boxcarful every minute. Where it is air-borne in the cycle, enough compressed air is introduced every minute to fill 50 average household rooms. Although great care is taken to prevent its escape, about 4 tons of catalyst worth $1500 at current prices is lost each day. To replace it, a large reserve is maintained. From the railroad cars in which it is shipped it is transferred by the suction of air from a blower exhaust to storage tanks such as the ones shown here. From the latter it is blown into the circulatory system, as required, by compressed air that is supplied either by the 15-pound turboblowers or the 45-pound reciprocating compressors that are part of the regular auxiliary operating equipment of each unit. Another use of compressed air is at the electrical precipitators where catalyst is recovered from flue gases passing over from the regenerator. The air flows in through insulator housings to keep the catalyst and gases inside.

Cracking (T.C.C.) Process. As in the fluid process, the catalyst is circulated, but it is in the form of beads or pellets instead of powder, and at any stage in its cycle where it will not flow by gravity it is moved by mechanical conveyors instead of in a stream of air or vapor. The development of the T.C.C. Process was headed by the Research and Development Department of the Socony-Vacuum Oil Company. The research entering into it included running a 500-barrel-a-day plant for a period of two years. The first commercial-size unit began operating on October 7, 1943, and numerous others have since been placed in service. The pelleted catalyst has high catalytic activity and great mechanical strength, with maximum resistance to loss by attrition. As in the Houdry and fluid processes, compressed air is used for burning the carbon off the catalyst. The T.C.C. Process is licensed by the Houdry Process Corporation, and most of the plants that utilize it have been designed and constructed by The Lummus Company.

A colored flow diagram of a Fluid Catalytic-Cracking plant, accompanied by explanatory notes, appears elsewhere in this article, so no attempt will be made here to go into all the details of the cycle. The regenerated catalyst flows by gravity from the regenerator to join the oil charge being pumped into the reactor through two feed lines. The catalyst descends in two vertical pipes, and to prevent it from packing and clogging provision is made for the introduction of compressed air at 45 pounds pressure at various points. Such air is also made available at two or three other places where the catalyst might otherwise not flow freely at all times. When the catalyst joins the oil it is hot enough to vaporize the charge, so no external heat has to be employed.

Within the reactor the catalyst is suspended in the rising vapors. This affords ample opportunity for the fullest possible contact, and thus the desired degree of cracking is obtained. The temperature within the reactor is around 975-1000°F., and this contributes to the speed of the cracking reaction. The mixed vapors and catalyst tend to rise to a certain level, after which the catalyst disengages to form a "bed." As the charge is continually fed into the reaction chamber a nearly equal amount of spent catalyst is withdrawn from the bed and flows down through a steam stripping zone and into a standpipe extending from it. The spent catalyst carries the coke (carbon) produced in the cracking reactions.

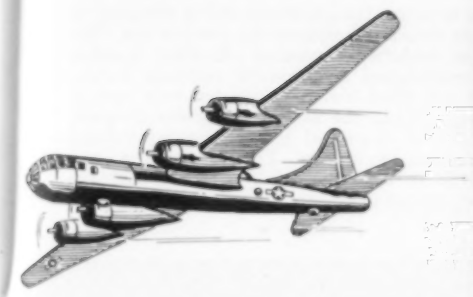
From the standpipe the spent catalyst is admitted through a slide valve into a pipe to which compressed air, normally at about 15 pounds pressure, is supplied by a turboblower. This aeration of the powdered catalyst reduces its density and causes it to move upward into the regenerator. The same air is utilized within the latter to burn the carbon deposit off the catalyst; but as its volume is not sufficient for that purpose, additional air, also from the turboblower, is introduced directly. A highly turbulent condition, similar to that in the reactor, is thus created in the regenerator, and this intimately mixes the air and catalyst and aids in burning off the carbon. The temperature in the regenerator may be as high as 1100°F., depending upon operating conditions.

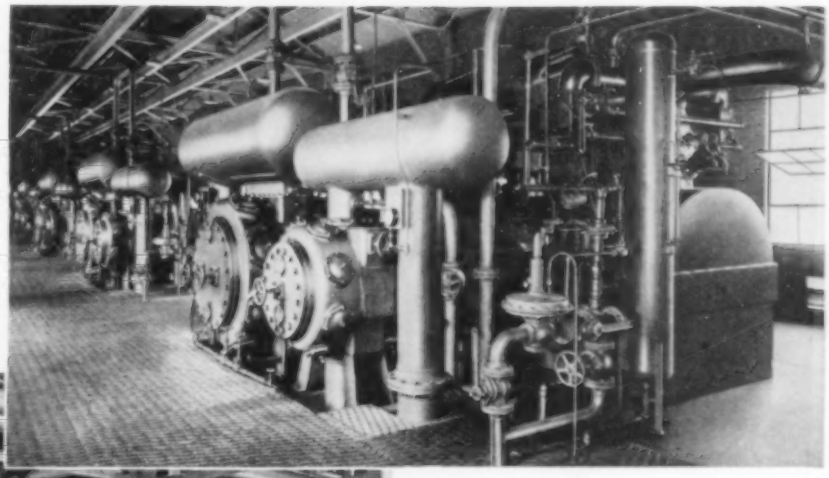
The catalyst enters the regenerator at the bottom by way of a central pipe and again forms a bed from which the regenerated catalyst is withdrawn and passes downward through vertical legs to join the oil being charged into the reactor, as already described. Some of the catalyst, it will be noticed on the flow diagram, is routed through a catalyst cooler and thence back to the regenerator. To facilitate this recycling, more air from the turboblower installation is introduced at the low point in the system. The heat the catalyst gives up in the cooler is used to develop steam. The cooler offers a means of controlling the temperature of the catalyst by varying the amount that is recirculated.

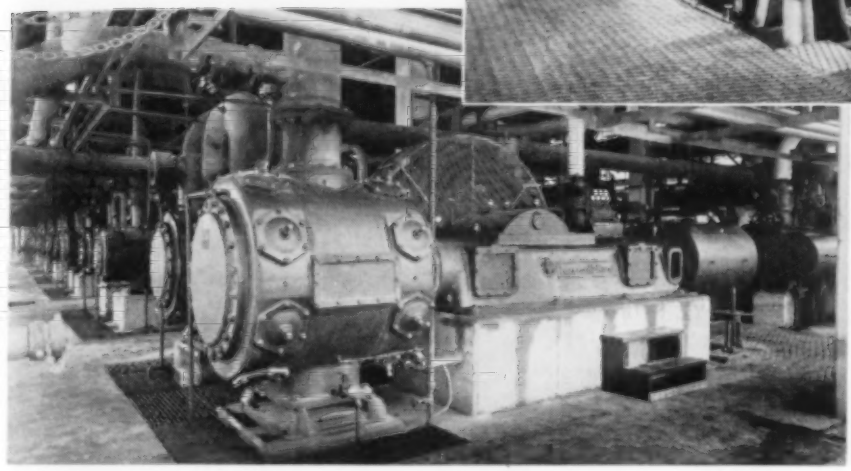
The flue gas derived from burning the carbon off the catalyst goes out at the top of the regenerator, first passing through a cyclone separator that removes most of the entrained catalyst. The gas is then sent through a cooler, where more steam is developed. From this cooler and the one previously mentioned is ordinarily obtained enough steam to drive the turboblower compressors and other auxiliaries, leaving a surplus for other services. After passing through the cooler the gas goes to a Cottrell electrical precipitator, where substantially all the catalyst still remaining in it is reclaimed. The gas is then released to atmosphere. The recovered catalyst is returned to the regenerator by a screw-type pump that is operated with the aid of compressed air which, under normal conditions, is supplied by the turboblower installation. However, a line from the 45-pound compressor is also connected to the pump for use in case the catalyst should become compacted and form a plug in the return line.

Returning to the reaction side of the cycle, we find that the cracked gases pass through a cyclone separator that removes all but a small amount of the catalyst and thence flow from the top of the reactor to a fractionator. In the latter they are separated into four fractions, one gaseous and three liquid. The liquids are heating oil, gas oil, and slurry, which contains the catalyst that was carried over from the reactor. The slurry is withdrawn from the bottom of the fractionator and is pumped back to join the fresh oil going to the reactor, thus reclaiming the catalyst.

The gaseous fraction obtained in the fractionator contains the gasoline hydrocarbons and others of value. Final separation is effected in a recovery plant, where the operations vary in accordance with the specific products, other than gasoline, that are wanted. Among the hydrocarbons are butanes and butenes, and some of these are alkylated to produce an aviation-gasoline component. The butenes are not only important for aviation gasoline but can, by dehydrogenation, be made into butadiene, which is the principal raw material required for







GAS COMPRESSORS

The gases produced in a "Cat" cracker are passed through a fractionator and there separated into one gaseous and three liquid products. The gases—consisting largely of butanes and pentanes, with some hydrogen, methane, inert gas, and steam—then go to a recovery plant, where they are formed into gasoline and other desirable products. The first step in recovering them is to compress them to facilitate their liquefaction. The compressor installation will vary with the process and also depends upon whether or not the plant has been built with a view to making automobile gasoline in the postwar period. In a typical recovery plant that is being operated primarily to make aviation-gasoline base stock and that serves a 15,500-barrel-per-day cracking unit there will generally be around 3200 horsepower of gas compressors. They are often steam-driven, because steam can be developed with surplus heat from the cracking process. The lower picture shows a battery of Ingersoll-Rand steam-driven compressors in the recovery plant of the Pan American Refining Corporation at Texas City, Tex. There are eight machines, each of approximately 400 hp. The gases are compressed from 0 to 60 pounds pressure in two stages and then put through an aftercooler, where some of them are liquefied through cooling. The remaining gases are then compressed to about 400 pounds pressure, again in two stages, where cooling results in further liquefaction. In other plants where there are surplus refinery gases it is economical to use gas-engine-driven compressors. Such an installation is shown at the top. It is in the Baltimore refinery of the Standard Oil Company of New Jersey and consists of five Ingersoll-Rand Type KVG 600-hp. machines. These units are designed to compress the gases from 0 to 110 pounds pressure.

synthetic rubber of the Buna-S type. Although butadiene is also obtained in other ways, much of the supply for our wartime rubber production has come from catalytic-cracking plants.

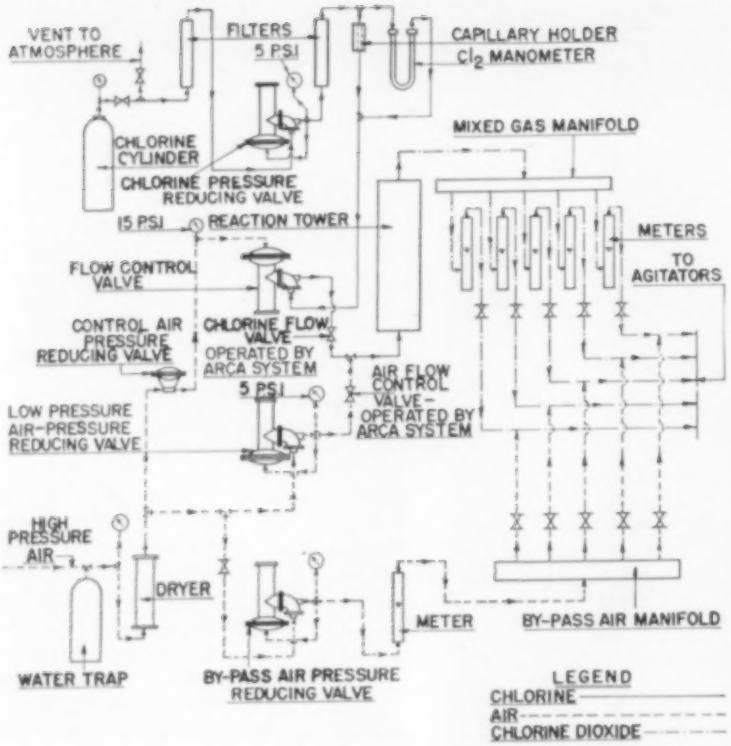
Because of the urgent need for aviation gasoline, all the Fluid Catalytic-Cracking plants in the first group were constructed the same in size in order to simplify and expedite manufacture and erection. These units were designed to process around 15,500 barrels of charging stock daily when turning out a base gasoline for a 100-octane finished product. Since then others have been built for daily capacities ranging from 2640 to 24,000 barrels, and one now in the design stage will handle 35,000 barrels. There is, accordingly, ample assurance that the process will be usable by small as well as by the largest refiners.

It should be brought out in connection with the subject of capacity that the amount of charging stock a plant will handle and the quantity of product it will turn out will depend upon the kind of base stock it is making. So far all the available capacity has been given over to the production of base stock for aviation gasoline of 100-octane rating or higher. When the war ends, however, many of the units will make base stock for a premium grade of automobile gasoline (probably 80-85 octane rating). As the base stock for that purpose will not need to be of the high antiknock quality demanded for aviation gasoline, the reaction can be carried on faster and the output will be greater. For example, a plant that now processes 15,500 barrels of charging stock a day may then handle nearly twice as much.

Another point that should be made plain is that these units can operate on various grades of charging stock other than the gas oil that is now customarily used in the production of aviation gasoline. When making automotive fuel, they are capable of processing what is known as reduced crude oil, which is the residue remaining after the lighter components have been removed from petroleum by conventional refining processes. A large part of the catalytic-cracking capacity that has been erected is in the eastern and southern parts of the country close to seaports. In the postwar period, however, the plants will serve all refining centers equally well.

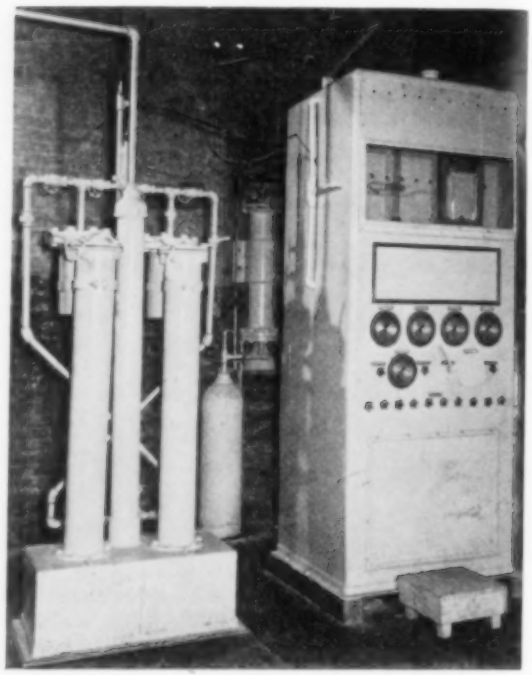
One-hundred-octane gasoline promises to exert a great influence on future commercial aviation. Limited supplies have so far prevented non-military planes from obtaining much of it, but in the years to come they will have all they want. The significance of this is that large aircraft will fly faster, carry heavier pay loads, and make fewer refueling stops along extended routes than they otherwise would. Also, but more gradually, the motoring public will fall heir to this superfuel. When the compression ratio of a conventional automotive engine is increased so that it may receive the power benefits of 100-octane gasoline it runs "rough" and noisy. It will therefore be necessary to develop engines that can use the fuel satisfactorily.

Although we have been talking about 100-octane gasoline, it is a fact that even higher-grade fuel is already being produced, and further progress will undoubtedly be made. Considering what petroleum technologists have already accomplished, we can expect them to keep on juggling hydrocarbons into more and more amazing useful products.



EQUIPMENT AND FLOW CHART

Below is shown the generator that is designed to provide chlorine dioxide at the point of use. The process consists in passing chlorine, together with compressed air, through reaction towers, which are filled almost to the top with sodium chlorite. When the salt in one tower is spent, that unit is by-passed for recharging without interrupting production. The generator is automatic in its operation and, together with the control equipment, occupies little floor space.



Anna M. Hoffmann

CHLORINE-DIOXIDE

Generator Brings New Reagent to Industry

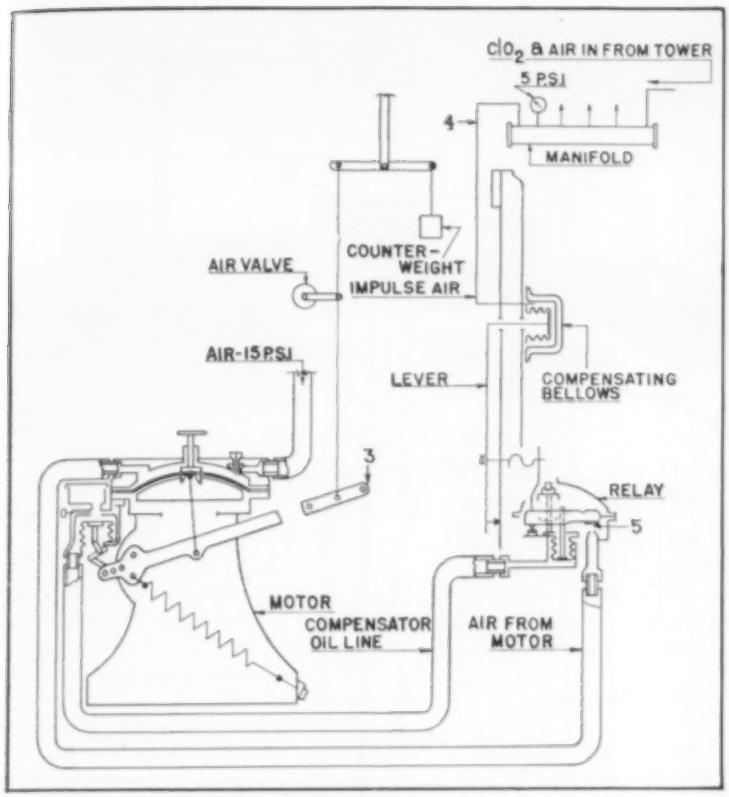
THROUGH the development of a new dry process and equipment, the Mathieson Alkali Works has given industry a means of generating chlorine dioxide that is expected measurably to widen the field of application of this powerful oxidizing and bleaching agent. Chlorine dioxide is inherently unstable, which necessitates producing it at the point of use. This was a drawback to its application, but is no longer so because it is now practicable for any plant to make its own supply for a specific purpose. Furthermore, the oxidizing power of chlorine dioxide in terms of "available chlorine" is said to be two and a half times that of chlorine.

The raw materials used are dry sodium chlorite and chlorine, and the equipment consists mainly of two vertical steel reaction towers or generators 3 inches in diameter and 4 feet high. These are lined with glass or stoneware and are filled almost to the top with flaked commercial sodium chlorite. Into the bottom of one of the towers is fed chlorine and compressed air, the latter at 5 pounds pressure and serving both as a carrier and a diluent for the chlorine.

The matter of dilution is one of prime importance from the safety standpoint, and is guaranteed by an automatic shut-off valve in the chlorine supply line. This valve is of a special type embodying a diaphragm which, when acted upon by air at 15 pounds pressure per square inch, exerts a total pressure of 750 pounds against a spring which, in turn, causes a lever to open a valve and thus to feed chlorine into the generator. Conversely, when the spring is released by shutting off the compressed air, the flow of chlorine to the tower is discontinued.

The chlorine dioxide produced in the first of the generating units is carried by the air current into and up through the second tower into a mixed-gas manifold for distribution by as many lines as operations may require. However, before it can be put to practical use, it is necessary to regulate the partial pressure of the chlorine dioxide in the gas-air mixture. This must be done for two reasons. In the first place, best results are mostly obtained with chlorine dioxide that is within a definite partial-pressure range. Secondly, if the partial pressure of the chlorine dioxide in the manifold exceeds 70 millimeters of mercury the mixture might explode. The highest partial pressure recommended for industrial applications is 30 millimeters.

Control of the partial pressure is maintained by varying either the input of chlorine, as already described, or the air flow. If the latter exceeds the amount that can be passed through the towers, the excess air is taken from the main supply system and fed through a pressure-reducing valve and a flow meter into a by-pass manifold, from which it may be dispensed into the individual chlorine-dioxide distribution lines by hand-operated valves. Another pneumatic feature of the equipment is the Arca controller that regulates the total pressure of the gases or the amount of chlorine dioxide produced. This device is connected to the air and chlorine pipes that feed the generator and is brought into play by the pressure of the gases in the manifold. When more than the desired volume of chlorine dioxide is being produced, one or several of the distribution lines are closed. This builds up the pressure in the manifold and, as an accompanying detailed drawing shows, causes the release of compressed air which, through various mechanisms,

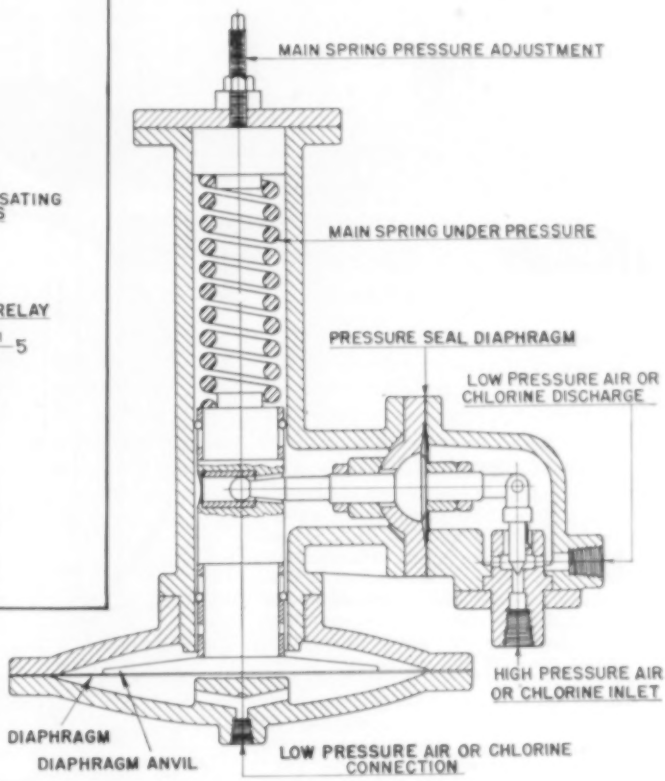


ARCA CONTROLLER

This unit regulates the production of chlorine dioxide by increasing or decreasing the flow of chlorine and air to the generator. It is brought into action by the pressure of the gas in the manifold, from which it is fed into the distribution lines. Any number of lines may be used to meet service requirements.

AUTOMATIC CONTROL

Diagrammatic cross section of the diaphragm type of valve that is used to regulate the flow of chlorine and the pressure of the air admitted to the generator. Compressed air serves both as a carrier and diluent for the chlorine.


MAIN SPRING PRESSURE ADJUSTMENT
MAIN SPRING UNDER PRESSURE
PRESSURE SEAL DIAPHRAGM
LOW PRESSURE AIR OR CHLORINE DISCHARGE
HIGH PRESSURE AIR OR CHLORINE INLET
DIAPHRAGM
DIAPHRAGM ANVIL
LOW PRESSURE AIR OR CHLORINE CONNECTION

closes the control valves that admit air and chlorine to the generator. On the other hand, if more chlorine dioxide is needed, the pressure in the manifold is reduced, thus automatically increasing the flow of air and chlorine.

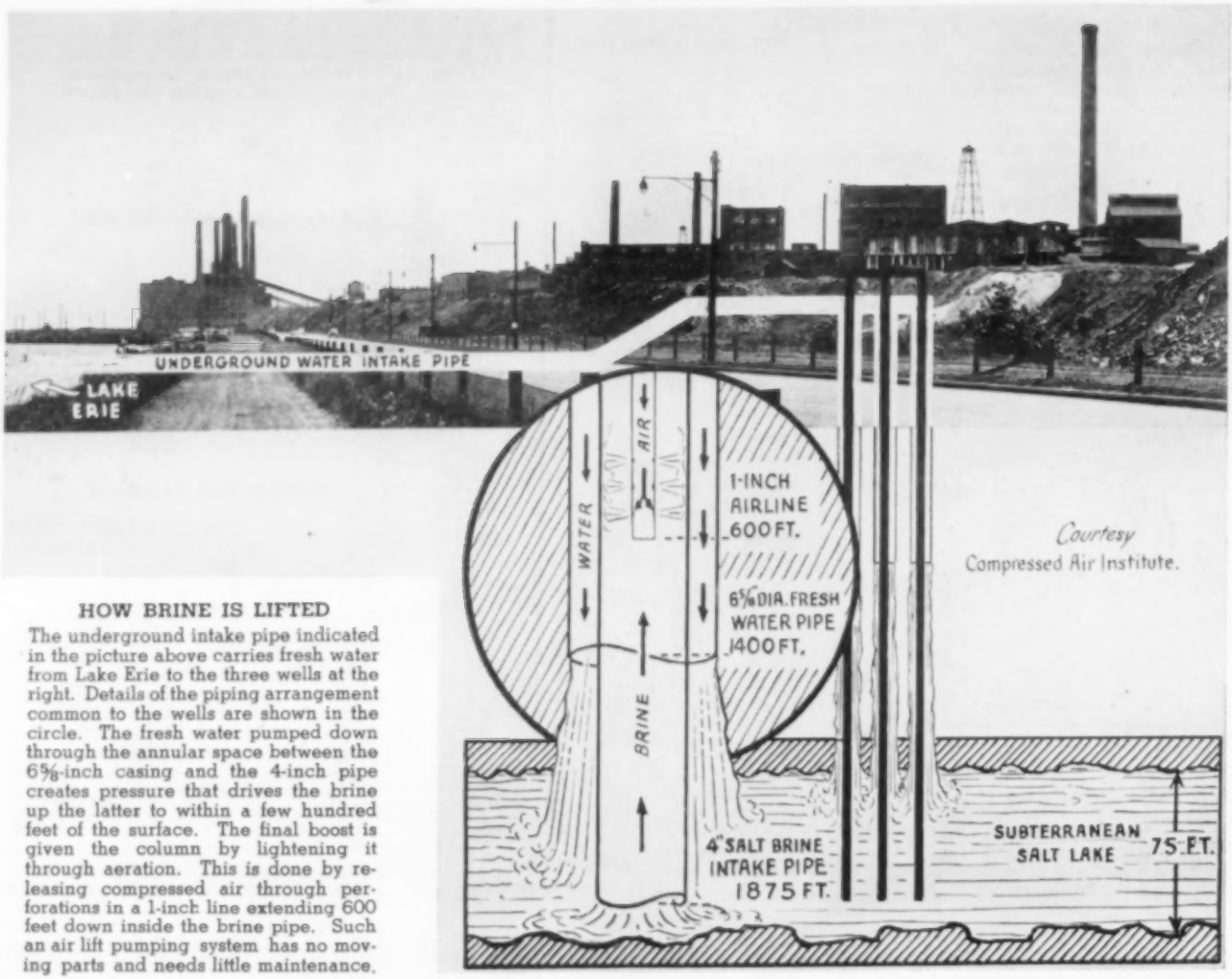
When the sodium chlorite in the first tower is spent, generation of gas is continued in the other tower only. In the meantime, the first unit is temporarily by-passed while the spent salt is removed and a fresh charge is put in. Then, by manipulating a set of valves, it is again connected into the system without interrupting gas production. Uniformity of the chlorine-dioxide content in the mixture is measured by sampling with an opaque Hempel tube, the gas being absorbed in a 10 percent potassium-iodide solution and titrated with a 0.1N or 0.01N sodium-thiosulfate solution. As a precautionary measure in case of accident, safeguards are provided which permit harmless discharge of the salts and gases. However, the possibility of an explosion is said to be remote because the chlorine is at all times properly diluted with air.

Chlorine dioxide has already proved itself of great value to public water works by removing from water the so-called chlorphenol flavor and flavors imparted to it by algae, thus improving its taste. It is also an efficient bleaching agent for products such as wheat and high-fat soybean flours, acidless tallow, wool grease, as well as for textiles and paper pulp. Its bactericidal properties promise many interesting applications, including the sterilization of tubercular sputum and the checking of blue mold in citrus fruits.

Searles Lake Becomes Important Producer of Lithium

SEARLES LAKE in California, famous as a source of borax and other substances, has become a primary producer of lithium which, until a few years ago, was mostly obtained from various complex lithium ores. The lake, really a solid mass of crystalline salts from 60 to 90 feet thick and covering an area of about 30 square miles, was long known to carry small amounts of this lightest of minerals in solution; but no serious attempt was made to recover it until 1942 when wartime requirements in the United States were found to exceed the domestic output by a large margin. Research work was then instituted by the American Potash & Chemical Corporation operating at Searles Lake, and in 1943 that organization built a pilot plant at Trona to determine the practicability of the resultant extraction process. This was followed by a large-scale recovery plant that was put in operation last year.

The raw material entering the Trona plant is in the form of a saturated brine, and the daily supply contains approximately 10 tons of a high lithium-bearing compound, or 2 tons of lithium, of which a considerable quantity is lost in the production cycle. Extraction is effected by treating the brine in pneumatic flotation cells. The yield is lithium-sodium phosphate, which is then thickened, purified by leaching with hot water, and filtered. The concentrate contains from 19 to 21 percent of lithium, which is far higher than that in the best lithium-ore concentrate. It is said to be unexcelled for making other lithium products because of the ease with which it can be processed. It is reported that the plant's present output is four times as great as it was at the start of operations and that its potential capacity considerably exceeds the lithium demand in the United States before the war.



HOW BRINE IS LIFTED

The underground intake pipe indicated in the picture above carries fresh water from Lake Erie to the three wells at the right. Details of the piping arrangement common to the wells are shown in the circle. The fresh water pumped down through the annular space between the 6⅝-inch casing and the 4-inch pipe creates pressure that drives the brine up the latter to within a few hundred feet of the surface. The final boost is given the column by lightening it through aeration. This is done by releasing compressed air through perforations in a 1-inch line extending 600 feet down inside the brine pipe. Such an air lift pumping system has no moving parts and needs little maintenance.

Cleveland's Liquid Salt Cellar

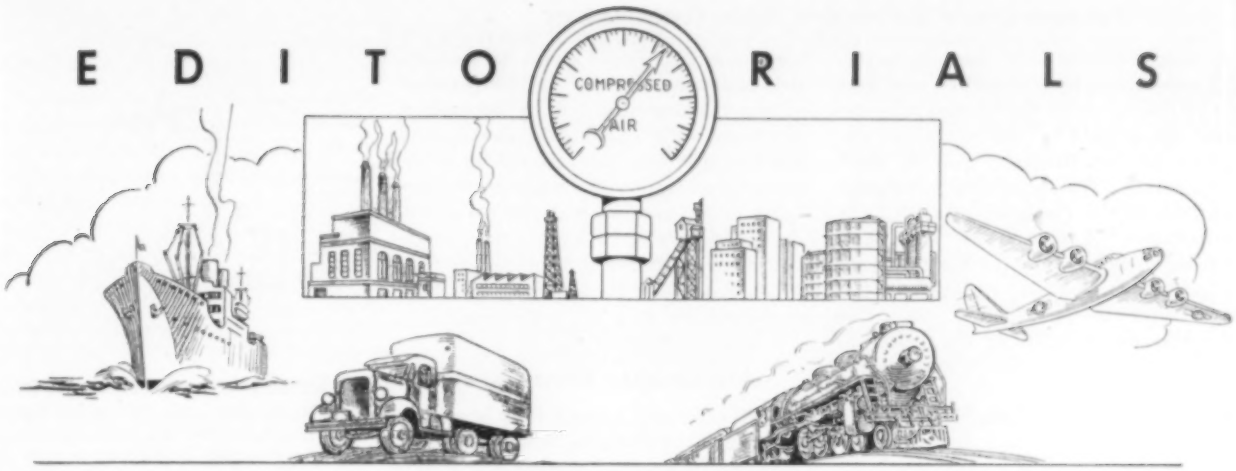
TWO thousand feet laterally from the edge of fresh-water Lake Erie and 1800 feet below the streets of Cleveland, Ohio, there is a deposit of liquid salt that is being mined from the surface through pipes 6⅝ inches in diameter. Fresh water and compressed air are the inanimate miners employed. Aboveground there is no indication of the activity, and few of Cleveland's 1,250,000 citizens are aware that the industry exists. The enterprise is conducted by the Union Salt Company, a 40-year-old concern that is controlled by the Morton Salt Company of Chicago. Details of the operations are shown in the accompanying illustration. The surface buildings are located on East Sixty-fifth Street, and underneath them are three wells that tap the subterranean saline lake. Fresh water is pumped to them from Lake Erie through underground mains.

The 6⅝-inch pipes serve as casings for the wells and extend to a depth of 1400 feet in solid lime rock, leaving a 400-foot gap between their lower ends and the top of the salt cavity. In that section the wells are unlined and conform to the inside of the casing in diameter. In each of the latter is a 4-inch brine-delivery pipe that reaches to the bottom of the 75-foot-deep lake, and inside that pipe, in turn, is a 1-inch compressed-air line that terminates at a point 600 feet from the ground surface. Fresh water, under pressure, goes down the annular space between the casing and the 4-inch pipe and forces the brine surfaceward through the latter. There is not enough force to push it all the way up, however, so compressed air, under 170 pounds pressure, is released into the brine column through perforations in the bottom of the 1-inch pipe, thus lightening and lifting it the remainder of the distance. The air is compressed by four steam-driven machines. Two of these supply the requirements and the other two serve as standbys.

Each air lift raises about 75 gallons of brine per minute, and the consumption of air is approximately 1.9 cubic feet per gallon. The brine has an average salt content of 2½ pounds per gallon, and its specific gravity is 1.2. The three wells can flow around 13,500 gallons, or 135,000 pounds of brine per hour, and at that rate a day's production is 405 tons of salt. The brine is delivered to settling tanks and, after being chemically treated, is transferred to vacuum evaporating pans where the water is driven off. The refined salt is the common table variety and is packaged and marketed for domestic consumption and for use in steel mills, meat-packing plants, and elsewhere.

When the operation was started 40 years ago, the brine was recovered entirely by pumping fresh water down one pipe and brine up another, a method that necessitated shutting down all the wells when one required attention. The compressor plant was added 35 years ago and has been in service ever since. It is now possible to keep two wells at work while the third is being repaired.

EDITORIALS



FIFTY YEARS OF X-RAYS

WILHELM ROENTGEN was born an even hundred years ago, and just 50 years back, come November 8, he discovered the X-ray, for which new uses are continually being found. Roentgen was a German professor of physics and made his discovery while experimenting with a highly exhausted vacuum tube in the conduction of electricity through gases. The radiation behaved so peculiarly that he could not explain it, hence the name X-ray that he chose. The X-ray tube is a type of electronic tube, being one among some 1200 of them.

X-ray was first used in the field of medicine, and it is there that it is still of greatest benefit to mankind. Physicians, surgeons, and dentists turn to it more and more all the while, and it is applied to every part of the body as a means of detecting, and sometimes of treating, disease or injury. There was a time when X-ray work was done by almost anyone on a hospital's staff, but nowadays it is conducted only by specialists.

Modern industry makes use of X-ray to detect flaws in metals—an application that was not even within the imagination of its discoverer and his contemporaries. One of its first important large inspection jobs was that of checking the steel penstocks that serve to carry water under high pressure to the turbines at Boulder Dam. Since then it has been widely adopted in the manufacture of ships, airplanes, and other equipment for warfare, including, ironically, even the weapons and projectiles that have been employed to reduce to rubble some of the German cities where Roentgen carried on his research.

Modern million-volt X-ray machines that can inspect steel plates 8 inches thick in fifteen minutes are now widely used, making shadowy pictures called radiographs that formerly could not be obtained except with expensive radium. Two or three 2-million-volt units also are available to industry, and they can take a picture through 8 inches of steel in one minute. Even these are dwarfed by a 100-million-volt apparatus that has been developed by General Electric research workers. Details regarding it will not be made public until the war is over.

One of the spectacular uses of 1- and 2-million-volt machines is to be found in various ordnance plants where they inspect shells loaded with TNT. In this service they take pictures through 2 inches of steel. The time of exposure is eighteen minutes, and from 3500 to 4000 shells are inspected daily. Previously, the only method by which cavitation, porosity, and foreign materials in these shells could be detected was to saw a certain percentage of them in half, obviously a very slow and wasteful procedure.

OUR SUPERFUEL

AN ARTICLE in this issue gives the highlights of the development of 100-octane gasoline. To present the entire story would require many times the twelve pages we are able to allot to the subject. The importance of this fuel to the Allied cause has been brought out sharply by reports from Europe in recent weeks. Hundreds of German planes have been destroyed on the ground, unable to go aloft for lack of gasoline. In consequence, the once all-powerful Luftwaffe has virtually ceased to exist as a fighting threat. By contrast, the air over Germany is full of United Nations' planes using gasoline that was, for the most part, transported across the Atlantic.

The scope of the 100-octane industry in this country is unbelievably large. A year ago our refineries were turning out 400,000 barrels of aviation fuel a day. Now the capacity is probably 500,000 barrels, or 21,000,000 gallons, every 24 hours. This is nearly a million gallons an hour, or enough to fly 12,000 planes against the enemy every day. And more plants are being erected. Compare this with the statistics for 1938 which show that our entire military demand for aviation gasoline was 1,042,036 barrels in twelve months. Our refineries now turn out that much every two days!

When all existing and contemplated United Nations' construction is completed, about $900,000,000 will have been expended for new aviation-gasoline plants initiated since we entered the war. Approximately $760,000,000 of this amount will be for plants in the United States. Of the expenditures in this country, roughly $550,000,000 represents obligations of private companies, while $210,000,000 is the Government's investment. Thus, more than 80 percent of the 100-octane production facilities will be privately owned.

Because of the flexibility of modern equipment, the plants will not be white elephants when the war is over. In the first place, commercial and private enterprise will demand considerable amounts of aviation fuel. In the second place, the new catalytic-cracking units can be readily converted for peacetime use to increase both the quantity and the quality of postwar automotive gasoline. The same is true, to a certain extent, of the facilities that produce various types of blending agents required in 100-octane fuel.

FRANK E. KUTZ

OUR organization lost a highly esteemed former official through the death on April 15 of Frank E. Kutz. Mr. Kutz served as secretary of Compressed Air Magazine Company from the time of its incorporation in 1932 until last December. A native of Easton, Pa., he spent 51 years in the employ of Ingersoll-Rand Company and was secretary of that concern's Phillipsburg, N. J., plant most of that time. He retired from active duty last year and was living in Rochester, N. Y., at the time of his death. He was 71 years old.

Temperature Recorder Aids Steelmaker

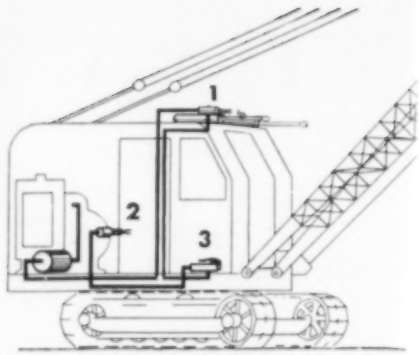
AN INSTRUMENT that can be immersed in a bath of molten steel and not be destroyed by the intense heat has been developed by metallurgical engineers of the Rustless Iron & Steel Corporation. The apparatus is designed automatically to measure and record the temperature of the metal, and thus eliminate the human equation from one of the most important variables in the manufacture of steel. In the past it has been the responsibility of the melter to determine when a furnace was ready for tapping, and he did this by studying the appearance of a small sample of molten metal withdrawn from a heat for the purpose.

The apparatus consists of a platinum thermocouple pyrometer which measures the temperature, and of an electronic recorder that is mounted near the furnace where the melter and the man handling the pyrometer will have no difficulty in seeing its large pointer and dial calibrated in degrees Fahrenheit. The pyrometer is attached to a 12-foot insulated pipe in which are the wires that lead back to the recording instrument and is made up of a platinum-rhodium thermocouple encased in a silica tube mounted in a block of graphite. This is the immersion head.

To take a reading, the head is dipped into the molten steel, and it takes the electronic instrument about 45 seconds, it is claimed, to record the temperature of the thermocouple. It is because of the speed with which both operate, and the fact that only the exposed tip of the silica tube containing the platinum wires is brought in contact with the hot metal, that it is possible to subject the pyrometer to the intense heat of the bath—as high as 3300°F.—without softening or destroying it.

Automatic Boom Stop

A BOOM stop control that is said to protect a crane against operational accidents from the moment the engine is started until the work is done has been developed by the Industrial Equipment Company. The system is actuated either with compressed air or vacuum and, according to the company, cuts off the power without shocks or strains the instant the boom reaches its maximum safe elevation. It can be furnished as a separate unit where a mechanical stop already is in use or as a combination automatic and mechanical stop. The accompanying drawing shows the latter installation, which consists of a boom stop valve, a clutch booster, and a bleeder valve. The stop valve is directly in line with the boom which, if raised beyond its safe limit, will contact the valve, thus applying pressure or vacuum and disengaging the master clutch through the medium of the clutch booster and arm. Provision is also made for the release of the master clutch in case the power lines are damaged. The bleeder valve is on the cab floor within convenient reach of the operator and serves to reëngage the clutch. Beyond occasional inspection, the Thomas Boom Stop requires no regular maintenance or lubrication, it is claimed. It has been endorsed by the Industrial Accident Commission of the State of California.

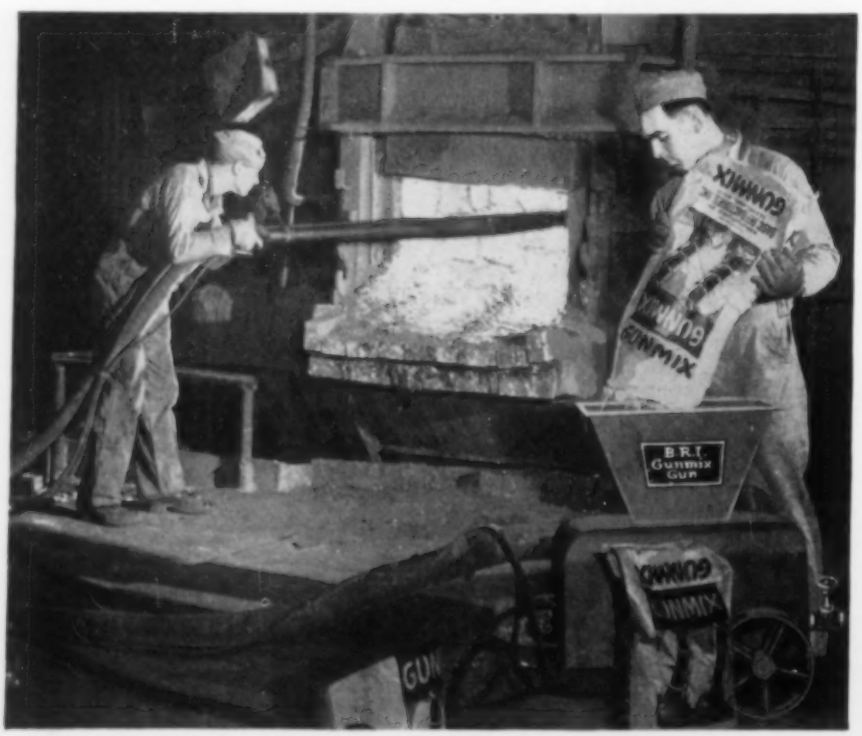


LAYOUT OF CONTROL SYSTEM

1– Boom stop valve; 2– clutch booster; 3– bleeder valve. All units of the system are connected by ½-inch copper tubing. The compressor or vacuum unit is mounted at the rear of the crane.

Refractory Blown into Place by Compressed Air

GUNMIX is the trade name of a new series of refractories for lining the walls of steel-industry melting furnaces. It has been developed by Basic Refractories, Inc., of Cleveland, Ohio. The first of the series is a magnesia-type refractory that is intended primarily for maintaining hot side walls of basic electric steel furnaces. Additional ones for other services will be introduced later. Gunmix is applied by means of a specially developed gun that utilizes compressed air and water.



The material, in dry, granulated form, is dumped from the sacks in which it is shipped into the hopper of the gun. The latter has connections for both air and water, which are obtained from plant distribution lines. From the gun, the Gunmix is blown by compressed air through a flexible hose to a nozzle where water under 30 pounds pressure is introduced, the amount admitted to give the desired consistency being under the control of the operator. The gun uses 130 cubic feet of air per minute at 80 pounds pressure.

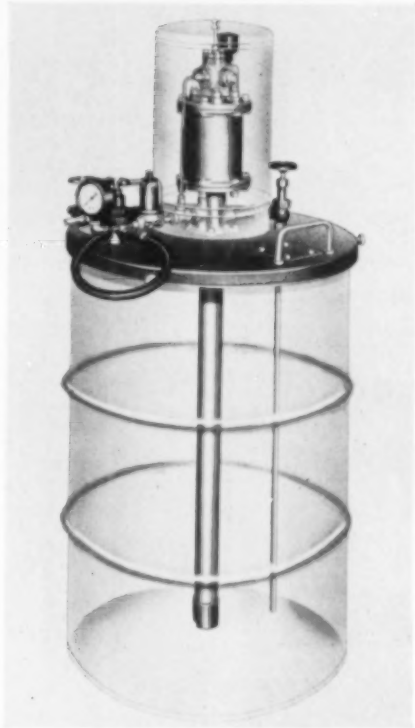
The operator directs the placement of the materials as desired. The gun is capable of mixing and delivering Gunmix quickly, so that the job can be done without delay. Furnace walls are usually hot when the refractory is applied. The latter adheres readily, without deflecting or falling from vertical walls, and also coalesces rapidly with a hot surface. Gunmix supplements Basic Refractories' product Ramix, a refractory for open-hearth furnaces that is rammed into place by means of air-operated equipment.

Industrial Notes

To prevent foodstuffs in dehydrating and similar plants from sticking to conveyor belts, trays, and the like, S. C. Johnson & Son, Inc., is offering a wax in liquid form for coating such of the surfaces as come in contact with the food. It is of a consistency that permits quick application by air spray and that forms a hard finish after drying. It is claimed that the wax will not evaporate in heated air, will not impair the taste of the food, and will also protect the equipment against corrosion and wear.

To meet the urgent demand by the armed forces for indicating instruments that will stand up under climatic conditions in the tropics, the General Electric Company has produced a line of 2½-inch panel instruments for direct-current voltmeters and ammeters and for alternating-current radio-frequency ammeters that are protected against the effects of humidity, moisture, chemical fumes, and other harmful agencies. The instruments are hermetically sealed in an inclosure consisting of a glass window, a metal ring, and a steel base all joined so as to remain tight under thermal and mechanical shock and fatigue vibration. The final assembly is evacuated, filled with an inert gas through a tube in the base, and sealed off at a pressure slightly above atmospheric. The instruments are made for flush mounting on nonmagnetic or steel panels and are shielded from stray magnetic fields. They meet the service requirements of American War Standard ASA Specification C-39.2-1944.

According to a recent announcement of the Alemite Division of the Stewart-Warner Corporation, its Versatal high-pressure spray pump, that has been used by the U. S. Navy for applying a secret antifouling paint to ships' bottoms, is now generally available. The unit is a radical departure from the conventional pressure-pot type and is designed to dispense and spray a wide variety of fluids of both heavy and light consistency under extremes of heat and cold. The materials that can be handled include paints, lacquers, mastics, sealers, insulating compounds, fiber and cement coatings, and petroleum emulsions.



STATIONARY TYPE

Spray pump of the barrel type showing fully housed pneumatic cylinder mounted on a circular head together with air regulator, air gauge, and transparent oil reservoir. The latter automatically feeds lubricant into the air stream admitted to the cylinder to insure smooth operation. Exhaust air from the cylinder is carried down into the tank through the pipe at the right and keeps the contents well mixed. The intake tube in which the piston moves is in the center. Dual outlets for compressed-air and material lines feeding the spray gun are at the left below the gauge. This unit is capable of pumping fluids through several hundred feet of hose.

These are discharged at a pressure 4½ to 5½ times greater than that of the air admitted to a double-acting pneumatic cylinder mounted on a circular head that is attached to a 12-gallon container, in the case of a portable type, or fits over the top of any standard 54-gallon barrel. The piston moves up and down in an intake tube that extends nearly to the bottom of the container and that delivers the fluid to threaded outlets to which the hose lines feeding compressed air and material to the spray gun are connected. By the use of manifolds, as many as six men can work from a single pump at a time. There is no need of maintaining an "air head" in the container, and this permits refilling without interrupting operations. Agitation is effected without mechanical aids, and both the pump and delivery lines can be cleaned by running the unit with the intake pipe immersed in a solvent.

With tires still a scarcity, there is every reason for protecting them from damage. One fruitful source of punctures is metal scrap, nails, etc., and to get rid of them, the Stearns Magnetic Manufacturing Company has put on the market what is designated as the Sweeping Magnet. The unit can be pushed or pulled around by a man like a lawnmower, or hauled back of a car, and is designed to clean up factory floors and outdoor areas, especially parking lots. Scrap is picked up by a drum with an 18-inch face and is deposited in a tray mounted back of it. The unit is permanently magnetized to eliminate the use of cables.

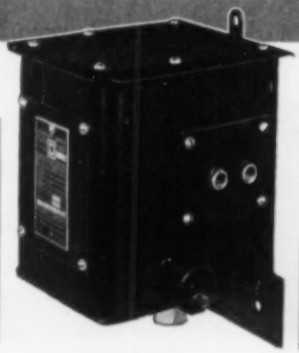
To keep busy rail lines in condition for the heavy traffic that war demands have placed upon them, American railways are putting great stress on roadbed maintenance. Unprecedented train movement, supplemented by the action of the elements, demands unusual precautions, and these are being exercised in a number of ways. The Santa Fe has

Marine PRESSURE SWITCHES

DRIPPROOF AND WATERTIGHT
HIGH SHOCK CONTACT BLOCK—
TWO OR THREE POLE—CLASS 9013
TYPE AW-H, MW-H, LW-H

ELECTRICAL RATINGS

Voltage	Single Phase A.C.	Polyphase A.C.	D.C.
110V.	2 H.P.	3 H.P.	1 H.P.
220V.	3 H.P.	5 H.P.	1 H.P.
440-550	5 H.P.	5 H.P.	.....
32V.	.....	.....	½ H.P.



• Built for Marine Service to conform with requirements for dripproof and watertight devices of shockproof construction. The switches differ from standard in the use of a special sheet steel enclosure and drip hood with gasket seal and a special high shock bakelite contact block in two or three pole form. The three types AW-H, MW-H and LW-H represent three diaphragm sizes and three range and differential variations. A release valve for air compressor service may be added to any of the types, as illustrated. Write for Bulletin 562.

REGULATOR DIVISION
SQUARE D COMPANY
DETROIT • MICHIGAN

been experimenting with cement grout as a means of consolidating the subgrade where it is not sufficiently stable. Apparently, the results have been satisfactory, for the road is now engaged in grouting a 100-mile stretch of busy double track underlain by soft and clayey soil. Holes are put down by air-operated hammers and are plugged by wooden stakes until the grouting gang comes along. The injection pipes are 5 feet long, except in areas where wet pockets are encountered. There 10-foot lengths are used. Ten crews are on the job and have covered 3 miles and more a week.

According to a recent announcement from the University of Minnesota, a new manganese mineral has been discovered in the Minnesota iron-ore country. It has been named groutite in honor of Dr. Frank F. Grout, head of the Minnesota Geological Survey. The mineral is said to be simple in composition, containing only manganese, hydrogen, and oxygen. It exists in beautiful large specimens of hundreds of jet-black crystals, and so far has been found only in the Cuyunga Range.

Users of sandblast cabinets may be interested in knowing how the Ithaca Gun Company is keeping its equipment in service condition. That concern has found that Compar plastic is 250 times as resistant to abrasive attack as boiler-plate and is placing a sheet of that rubberlike material on the perforated bottom of each of its cabinets. As a result of this protective measure there is less work stoppage because of need for replacements.

Glass resistant to hydrofluoric acid has been developed by the American Optical Company. It is a phosphorus-pentoxide and not a silica product and can be made by the regular methods of casting, cutting, molding, blowing, grinding, and polishing. Although the acid does attack it, the process is a slow one and the glass retains its transparency the while. Suggested products are sight glasses, gauges, laboratory ware, protective screens, goggles, and fume hoods for chemical plants.

Mobile crushing plants, complete with jaw and roll crushers, screens, conveyors, and washers, are at work at the front providing aggregates for roads, concrete structures, air bases, etc. Equipment of this type is made up of nine units which require as many flat cars to carry them to the points of embarkation. The whole plant moves on wheels or caterpillar tracks and is capable of producing the different products—even sand—that may be required. It has a rated capacity of 150 tons of aggregates an hour.

do your MENTAL BUYING now!

In making your post-war plans, you'll want to install the light-weight pipe that can give you the stepped-up performance required for more profitable operation.

No other light-weight pipe combines all the advantages of Naylor's exclusive Lockseam Spiralweld structure. You'll like its light weight. Its greater strength. Its speed of installation. Its leaktightness. Its extra safety. Its revolutionary coupling methods. Its savings, high salvage and re-use value. It will pay you to do your mental shopping now and include Naylor Pipe in your post-war plans.

Specify Naylor Pipe for high pressure hydraulic lines, high or low pressure air and water lines, de-watering, drainage, ventilating and sludge lines. Sizes from 4" to 30" in diameter, lengths up to 40 feet. All types of fittings, connections and fabrications.

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Prepared for ACTION!

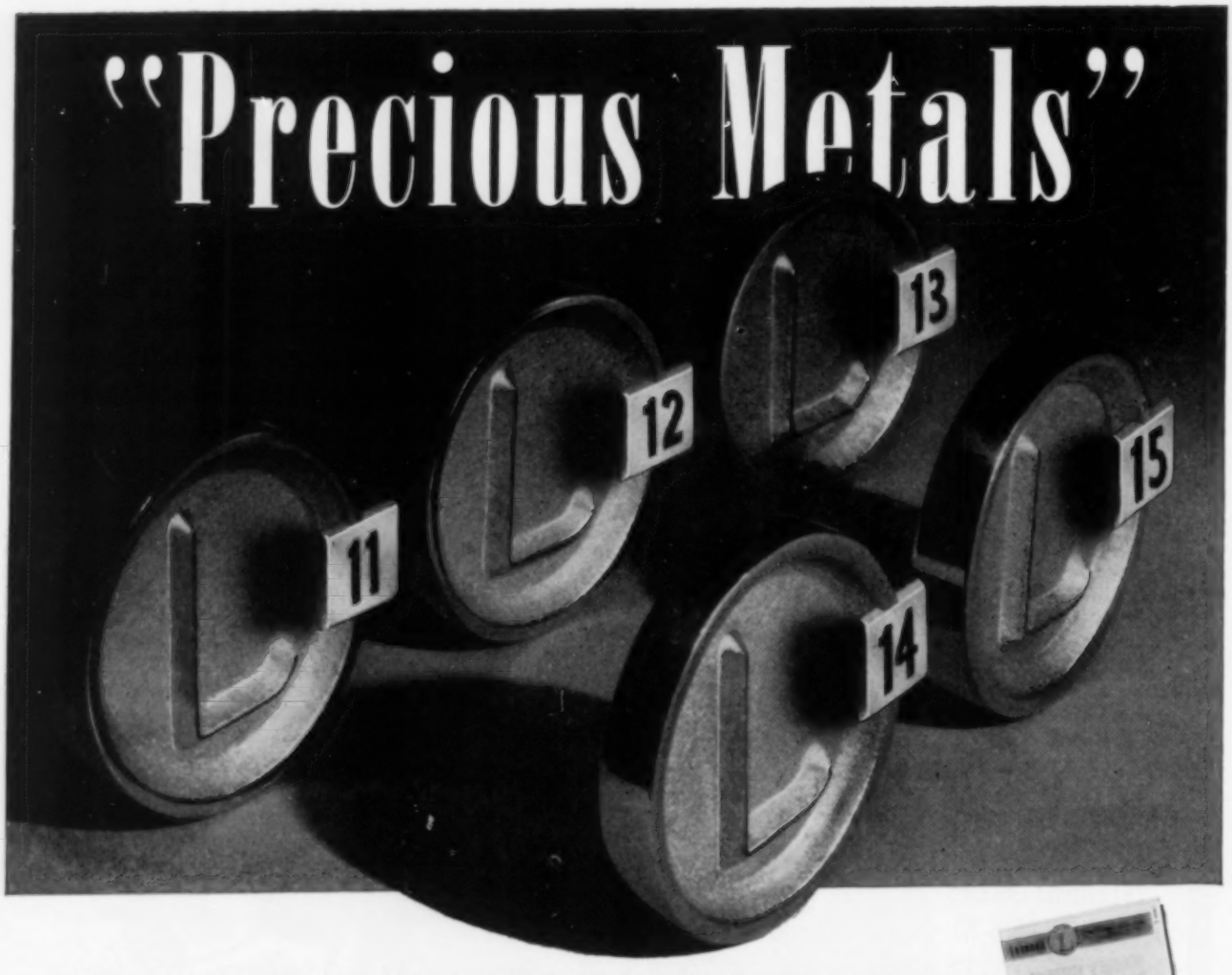
YOU'RE SURE TO GET TOP-FLIGHT DRIVE PERFORMANCE WHEN YOU SPECIFY ALLIS-CHALMERS TEXROPE V-BELTS . . . EACH BELT IS DESIGNED, TESTED AND BUILT TO SOLVE SPECIFIC DRIVE PROBLEMS

REALLY BAD OIL CONDITIONS ARE MY OBJECTIVES. I'M SUPER-7 OIL-PROOF...MADE OF SOLID NEOPRENE. GRIMY LIQUIDS DON'T BOTHER ME.
OIL
HEAVY LOADS? EASY! MY STEEL CABLES ADD POWER, REDUCE STRETCH AND SLIPPAGE. I'M SUPER-7-STEEL.
SUPER-7 STATIC-RESISTING TALKING: MY BUILT-IN CONDUCTING ELEMENT CARRIES STATIC CHARGES TO MACHINES WHERE THEY'RE GROUNDED.
90% OF ALL OIL CONDITIONS ARE A CINCH FOR ME. NEOPRENE IS MY COVER..SUPER-7 OIL-RESISTING, MY NAME.
HOT-RUNNING DRIVES ARE WHERE I SHINE. 180°F IS JUST COMFORTABLY WARM FOR SUPER-7 HEAT RESISTING. THAT'S ME.
A 1771

IT PAYS TO MAKE ALLIS-CHALMERS YOUR V-BELT DRIVE HEADQUARTERS

Texrope Super-7 V-Belts result from the cooperative research of two great companies—Allis-Chalmers and B. F. Goodrich—and are sold exclusively by A-C.

"Precious Metals"



TO USERS OF STRAIGHT CHROMIUM STAINLESS STEEL CASTINGS

LEBANON'S series of straight chromium stainless steels . . . 12% to 30% chromium range . . . are highly valuable wherever their physical, machining and corrosion-resistant characteristics economically meet service conditions . . . and where nickel as an alloying element may be objectionable.

Choice of five alloys in this Lebanon group makes possible the selection of the right steel for any specific service condition within a broad general range. Substances successfully handled by castings of these various Circle (L) straight chromium stainless steels include nitro cellulose, nitrated compounds, alcohol, ammonia, fruit juices, lubricating oils, steam, soap, lye, vegetables, fresh water, vinegar, salt spray, organic chemicals and acids, fused salts, non-ferrous metals and certain sulphuric acid solutions.

Correct selection of alloy for the particular service conditions is, of course, an essential. This is best done through consultation with a Lebanon metallurgist or foundry engineer.

NEW BULLETIN

Describes all five Lebanon Circle (L) Straight Chromium Stainless Steels. Shows Chemical Analyses and Physical Properties at a glance. Write for free copy today.

Lebanon Circle (L) 11. 18% to 20% Chromium; .30 Carbon Maximum

Lebanon Circle (L) 12. 12% to 14% Chromium; .12 Carbon Maximum

Lebanon Circle (L) 13. 12% to 14% Chromium; .25 Carbon Maximum

Lebanon Circle (L) 14. 21.50% Chromium; 1% Copper; .30 Carbon Maximum

Lebanon Circle (L) 15. 26% to 30% Chromium; 1.5% Nickel Maximum; .30 Carbon Maximum

LEBANON STEEL FOUNDRY LEBANON, PENNA.

ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

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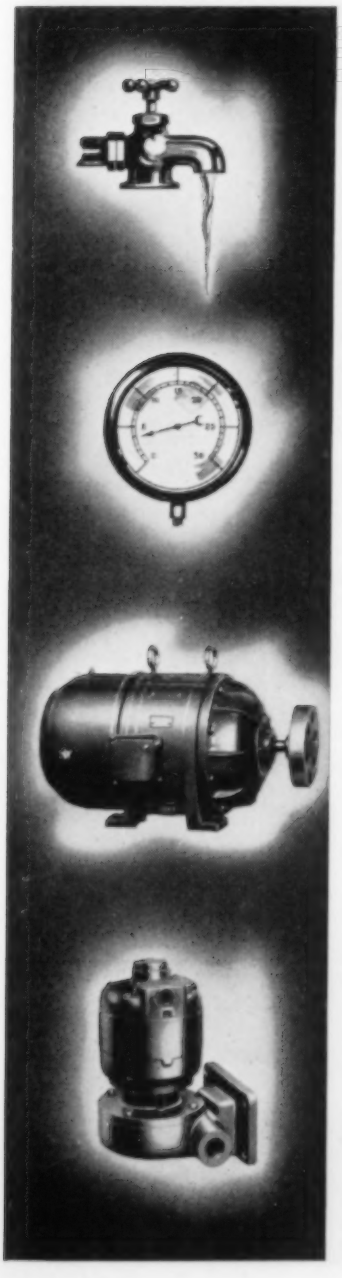
Ingersoll-Rand builds the most complete line of centrifugal pumps that is available today. Its engineers are equipped to solve difficult pumping jobs involving special equipment. Hundreds of thousands of standard machines and thousands of special units are helping satisfied customers to lower their liquid moving costs.



ANY DESIRED CAPACITY

Single pumping units with capacities from 1 to 100,000 gallons per minute are available. Multiple unit installations may run to unlimited capacities.

ALL COMMERCIAL PRESSURES

Single and multi-stage pumps furnish any desired pressure. Pumps for pressures as high as 3,000 pounds per square inch are furnished for central stations and oil refineries.

ANY TYPE OF DRIVE

I-R pumps are available with direct-connected or direct-coupled electric motor, steam turbine and engine drivers.

EVERY CONCEIVABLE SERVICE

Ingersoll-Rand pumps serve wherever liquids must be moved—from coolant for the tiniest machine tool to circulating condenser water for the largest generating station.

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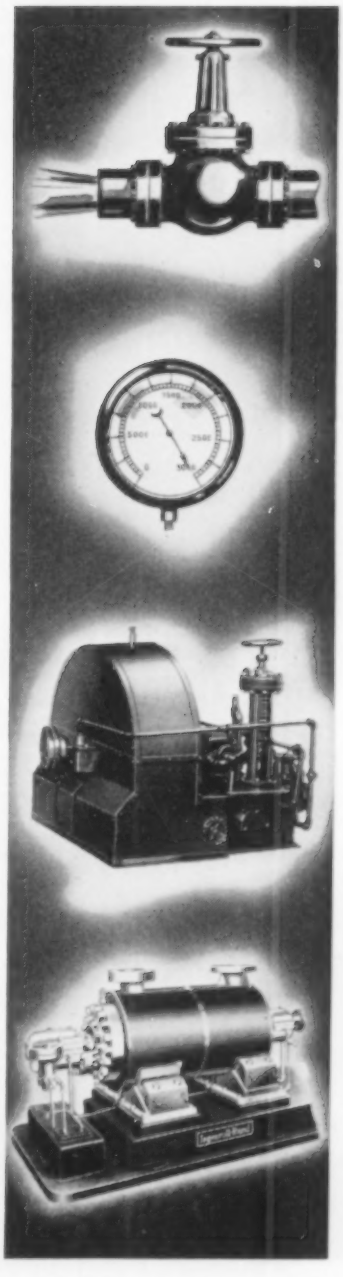
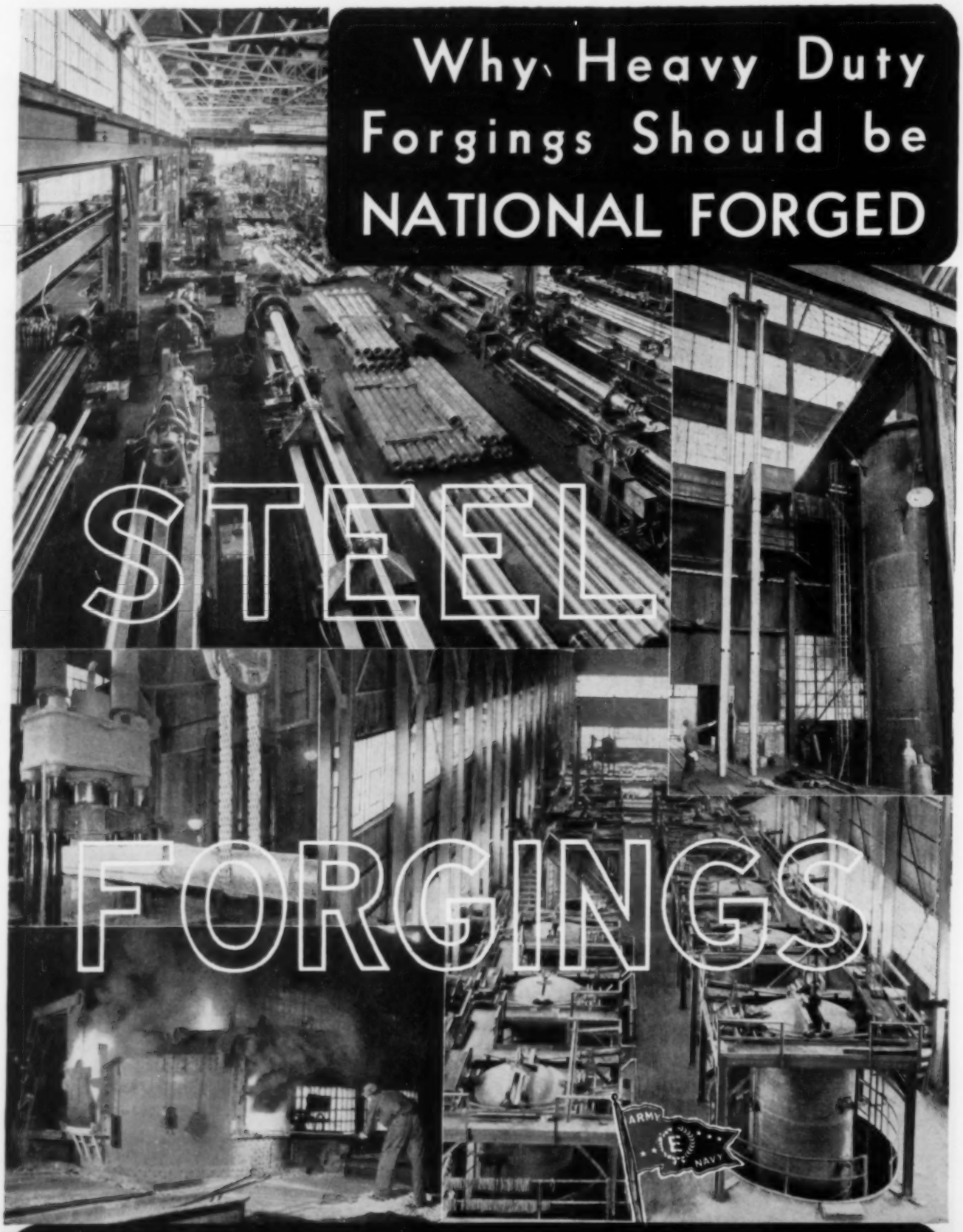




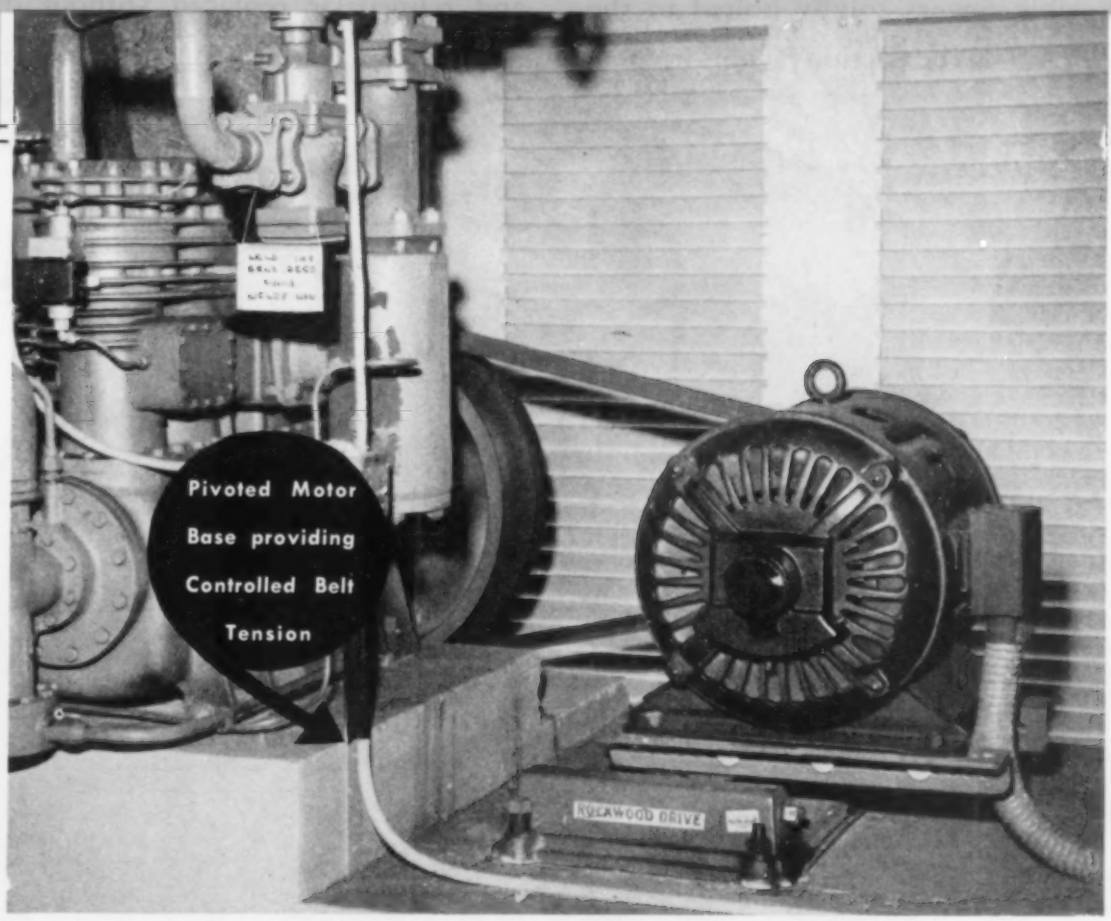
NATIONAL FORGE & ORDNANCE COMPANY

IRVINE, WARREN COUNTY, PENNSYLVANIA

Rhoads TANNATE-ROCKWOOD FLAT Belt Drive

The Right Combination

for an efficient, Trouble-Free Compressor Drive



A Tannate Rockwood Short Center Drive will maintain a high efficiency *steadily* over a long period, with little maintenance.

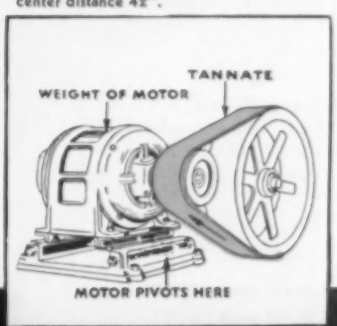
Correct belt tension is established by the pivoted motor base; as the weight of the motor on the pivoted Rockwood base automatically adjusts the tension to varying load conditions.

High efficiency at peak load is assured and that means maximum performance of compressor or fan.

And Tannate *keeps* the firm pulley grip built in by its special tannage. Users report a life 25% and more over ordinary belts. One large user reports that 35 fans using Tannate-Rockwood drives have run over 7 years, 24 hours a day and every day of the year except the seven Christmas days.

A Rhoads service engineer will gladly call and discuss the possible uses of Tannate-Rockwood Compressor Drives in your plant. Ask for details.

9" heavy double Tannate belt on a 50HP, 1750 rpm motor. No. 10 Rockwood bases. Motor pulley 9", compressor pulley 28", center distance 42".



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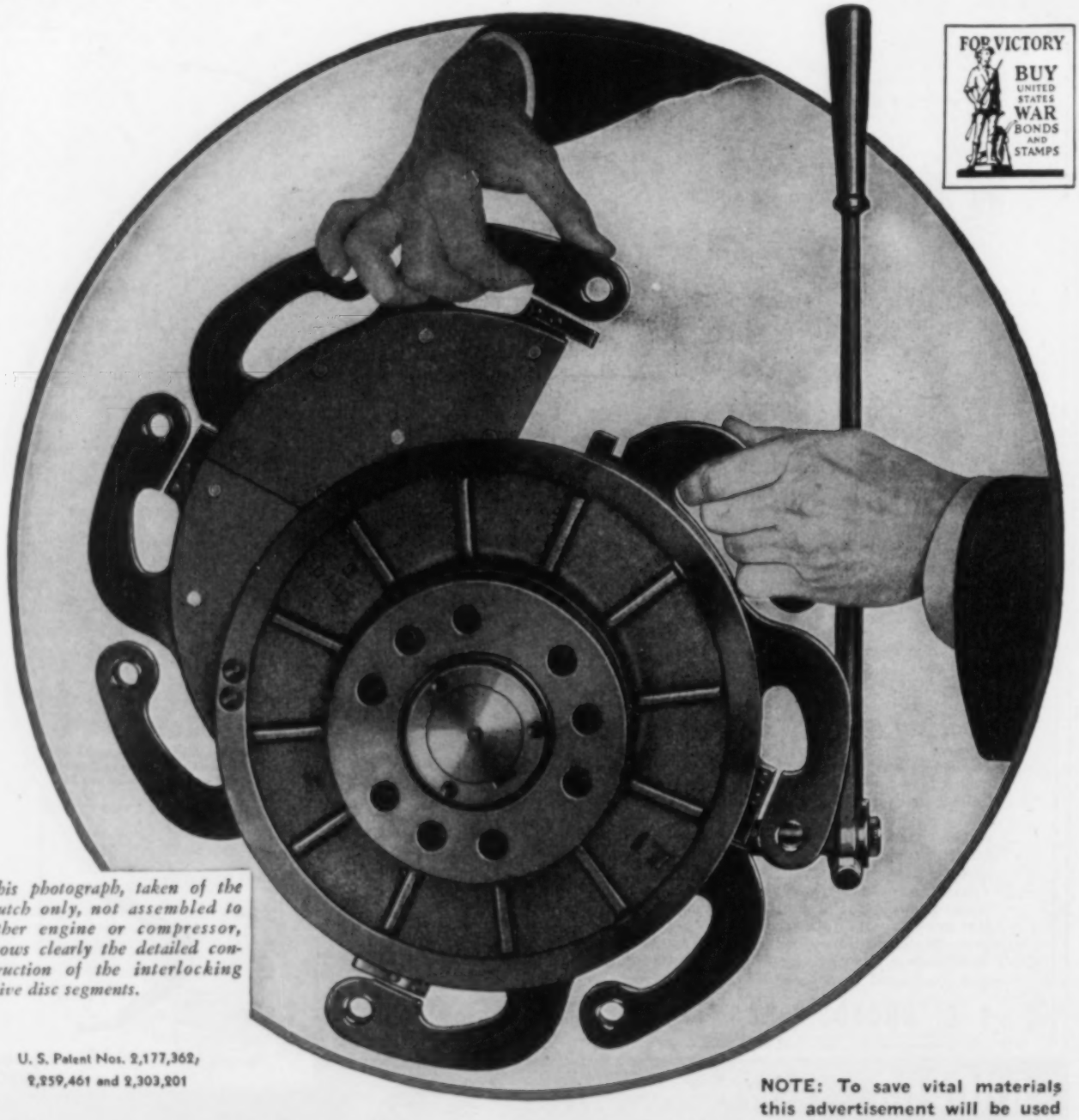
RHOADS

Tannate-Rockwood

SHORT CENTER DRIVE

FLEX-DISC CLUTCHES

Used on the entire line of I-R *Mobil-Air* Compressors, have a time proven drive disc with flexible fingers solidly bolted to the fly wheel. When the friction facings become worn these drive discs, which are quickly detachable in segments, may be removed and relined or replaced without disconnecting the engine from the compressor.



FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

This photograph, taken of the clutch only, not assembled to either engine or compressor, shows clearly the detailed construction of the interlocking drive disc segments.

U. S. Patent Nos. 2,177,362, 2,259,461 and 2,303,201

NOTE: To save vital materials this advertisement will be used for "the duration."

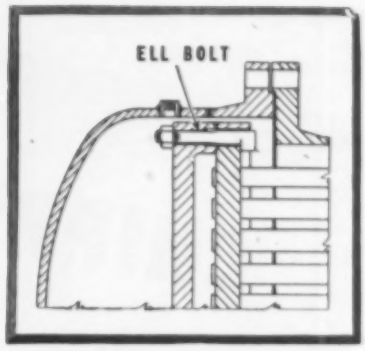
C. M. EASON, INDUSTRIAL CLUTCH CO.

Waukesha Wisconsin

ELL BOLT
CONSTRUCTION

a feature of the Patented

VOGT HEAT EXCHANGER
Floating Tube Sheet Assembly



Patent Nos.
1,895,735
2,232,478

Assures
NO LEAKS HERE

YOU LOSE when an exchanger leaks . . . . with the possibility of fluid contamination, or shut down for repairs.

None of these evils need plague you when you employ the Vogt patented floating tube sheet assembly because there is no distortion of a split ring to worry about in making up the joint time after time. Its easy to make tight and it stays tight!

Critical materials are saved too because the design makes possible a smaller diameter of shell through reduction of the dead space between the shell and the tube bundle.

Saves
FLUID CONTAMINATION
•
FREQUENT SHUTDOWNS
•
CRITICAL MATERIALS

BUY WAR BONDS

Our new bulletin HE-5 is a pictorial presentation of standard and special types of Vogt Heat Exchangers. Write for a copy on your letter head.

HENRY VOGT MACHINE COMPANY
Incorporated
LOUISVILLE 10, KENTUCKY

Branch Offices: New York, Philadelphia, Cleveland, Chicago, Dallas.

Vogt *Heat Transfer* EQUIPMENT

CHIPPER SAVES $1050.00 *by using* 90 LBS. AIR PRESSURE

Look what happens to the C. E. (cutting efficiency) of a hammer when the air pressure at the tool drops below 90 pounds:

90 psi . . . 100%
80 psi . . 83½%
70 psi 63%
60 psi 50%

CUTTING EFFICIENCY
The evaluation of work actually done by a chipping hammer

Let us assume that a chipping hammer operator earns $2100.00 a year. If he is permitted to use a hammer that is only 50% efficient, the loss will be $1050.00. For a plant using only 20 chippers, the excess labor costs would amount to more than $20,000 a year. Ingersoll-Rand "Cutting Efficiency Service" will help you save these dollars.

Air pressure is but one of the important factors that is checked by our "Cutting Efficiency Service." Other factors include — selection of proper tool — correct chisel shapes — efficient layout — proper repair methods — standard tests for C. E., etc. Let our service engineers help you analyze your situation.

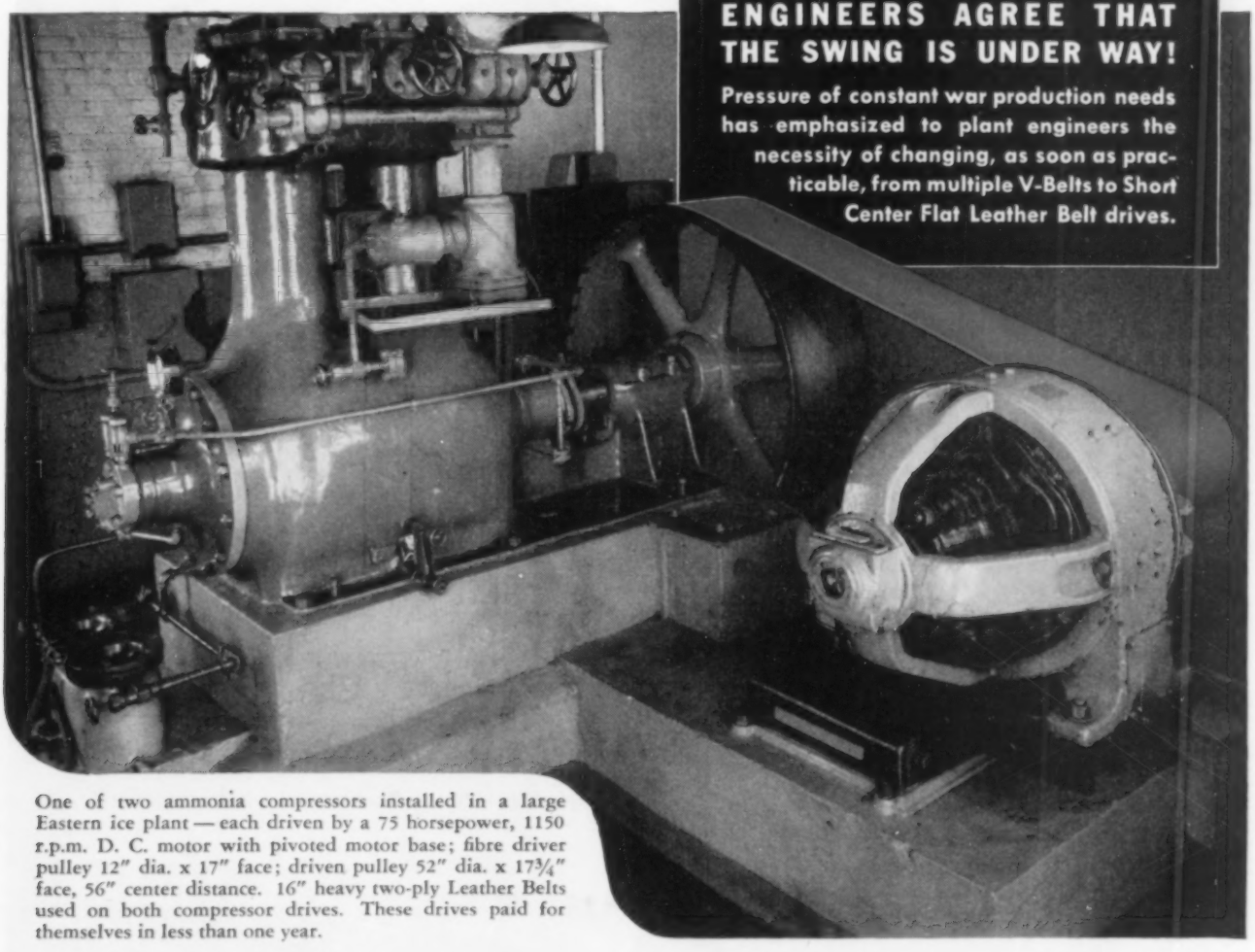
Send for our handy two-color wall chart on Chipper Repairs, Form 5634.

Ingersoll-Rand
11 BROADWAY, NEW YORK 4, N. Y.

8-563

ONLY *Leather Belting* CAN DO THIS JOB PROPERLY

"INDUSTRY LEARNS BEST FROM EXPERIENCE"



ENGINEERS AGREE THAT THE SWING IS UNDER WAY!

Pressure of constant war production needs has emphasized to plant engineers the necessity of changing, as soon as practicable, from multiple V-Belts to Short Center Flat Leather Belt drives.

One of two ammonia compressors installed in a large Eastern ice plant — each driven by a 75 horsepower, 1150 r.p.m. D. C. motor with pivoted motor base; fibre driver pulley 12" dia. x 17" face; driven pulley 52" dia. x 17¾" face, 56" center distance. 16" heavy two-ply Leather Belts used on both compressor drives. These drives paid for themselves in less than one year.

ANOTHER Proof that Leather Belting is Best for You, Too... A famous Eastern College, founded 1848, and having annual enrollment of over 2,000 students, had four drives in their boiler house each equipped, prior to 1939, with multiple V-Belt drives. Because of serious slippage at full load and short life of belts, all four were then changed to short center flat Leather Belt drives. The Chief Engineer at the College said: "We know now that flat Leather Belting, with pivoted motor base, when properly installed, is the most effective drive. After a full and fair trial with multiple V-Belts, we are glad that we changed to Leather Belting." . . . Remember: The pulley-gripping capacity of Leather Belting actually increases as the load is increased. Leather Belting absorbs shocks — saving wear on motor and machine bearings. You'll have fewer shutdowns with Leather Belting, and it's easy and comparatively inexpensive to install.

LEATHER BELTING IS LONG LIVED. IT CAN "TAKE IT."

AMERICAN LEATHER BELTING ASSOCIATION • 41 Park Row, NEW YORK 7, N. Y.

MAXIM
HAS THE "KNOW-HOW"
As the pioneer Company in the development and manufacture of silencing equipment, Maxim has experience "plus" to offer in solving your silencing problems. Maxim exhaust and intake silencers, spark arrestors, steam blow-off silencers and the new Heat Recovery silencers are in operation today in industry from coast to coast. When the problem is silencing, consult Maxim.

ARMY E NAVY

MAXIM

DR. SHUSH

THE MAXIM SILENCER CO. • 85 HOMESTEAD AVE., HARTFORD, CONN.

Copper for the Cauldrons of War

BUCYRUS MONIGHAN

Close to a steep bank on a narrow bench atop a 225-foot ore dump, a 5-W Bucyrus-Monighan walking dragline with 4-yard bucket and 135-foot boom daily salvages tons of vital copper in Montana. On every pass it reaches out some 200 feet, loading to cars more than 200 tons, hourly, of copper bearing "waste" deposited in generations of mining. With the efficiency for which Bucyrus-Monighans are famous, it helps recover every possible ounce of the now-precious ore for the myriad needs of a giant war machine. Large bearing area for sure footing, maneuverability for by-passing trouble, long reach, strong construction, fast action, easy operation — these are the requirements and the Bucyrus-Monighan has them all. On this work — as on a host of tough jobs all over the world — the "years ahead" performance that only Bucyrus-Monighans can deliver is essential.

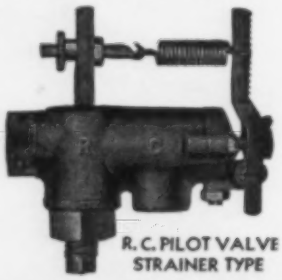
G-55

AVAILABLE with
BOOMS
80 ft. to 250 ft.
BUCKETS
3 to 25 Cu. Yds.

sold by
BUCYRUS-ERIE COMPANY SOUTH MILWAUKEE, WISCONSIN

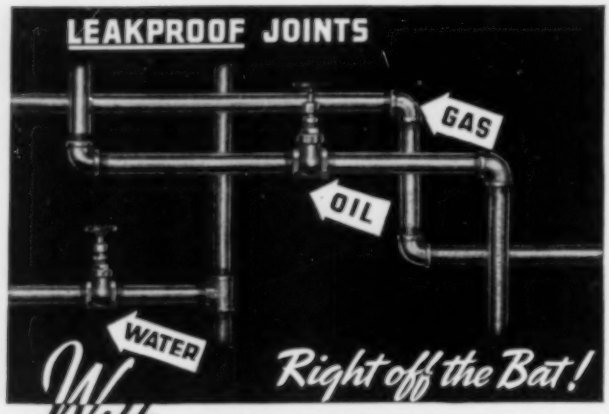
R. C. PILOT VALVES FOR POSITIVE CONTROL

R-C Unloader Pilot Valves (plain or strainer type) are standard on many leading compressors . . . installed as replacements on thousands of compressors in all parts of the U. S. A. and overseas. The R-C valve—positive in action—cannot chatter . . . it's always in open or closed position. Adjustment is provided for any unload-to-load range from 3% to 30% of maximum receiver pressure. Install an R-C Unloader Pilot valve—let performance prove its value. Specify air pressure and range of on-and-off operation desired. Write for price and recommendation.



R. C. PILOT VALVE STRAINER TYPE

R. CONRADER CO.
1207 FRENCH STREET · ERIE, PA.
PILOT VALVES for Portable and Stationary Air Compressors provided with Unloaders



With **JOHN CRANE** *Right off the Bat!*

Insoluble **PLASTIC LEAD SEAL**

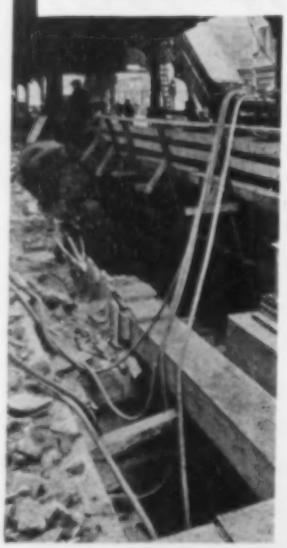
- *Insoluble* in water, gasoline, propane, CO^2, etc. Won't wash out.
- *Seals quickly;* fills clearances and imperfections.
- *Stops galling, rust.* Never hardens; joints easily taken apart later.
- *Ready for use,* in 1, 5, 7-lb. cans.

Order a trial can of Plastic Lead Seal—watch it reduce maintenance in your plant or product.

CRANE PACKING COMPANY 1808 CUYLER AVE. • CHICAGO 13, ILL.
BALTIMORE, BOSTON, BUFFALO, CLEVELAND, DALLAS, DETROIT, HOUSTON, LOS ANGELES, NEW ORLEANS, NEW YORK, PHILADELPHIA, PITTSBURGH, SAN FRANCISCO, ST. LOUIS, TULSA
CRANE PACKING CO., LTD., Hamilton, Ontario, Canada
Branches: Montreal, Toronto, Vancouver

GOODALL AIR HOSE

Built for Extra Service and Safety



The tougher the job, the plainer the proof that Goodall quality in Air Hose means an *extra* measure of strength and durability. Available in several types of wrapped duck construction, some all-Synplastic. "Subway," "Allgood Cord" and "Oil King" are the brand names to use when ordering.

Contact Our Nearest Branch or Main Office for Details

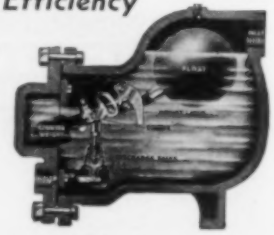
GOODALL
RUBBER COMPANY INCORPORATED
The Goodall-Whitehead Companies
Philadelphia. Trenton. New York. Chicago. Pittsburgh. Boston.
GOODALL RUBBER CO. of CALIF. Factory - Trenton, N. J.
GOODALL RUBBER CO. of TEXAS Established 1870

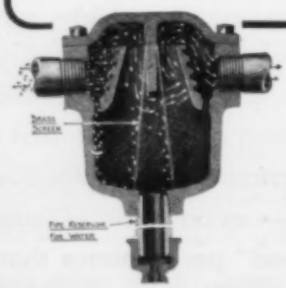
2 *Dependable Units to Help You*

KEEP AIR LINES CLEAR

and Increase Efficiency

NICHOLSON
COMPRESSED AIR TRAP
Model "JR", right, provides long, trouble-free service. For pressures to 200 lbs. Intermittent discharge; welded stainless steel float; water-sealed discharge valve.





NICHOLSON
AIR SEPARATORS
Removes moisture, oil and grit; supplies clean, dry air to pneumatic tools, greatly prolonging their life. Ingenious baffle and 4-layer filter of fine-mesh brass screen, easily removed for cleaning. Inlet and outlet tapped for ¼", ⅜", ½", ¾" connections.

Write for Catalog 444 or See Our Catalog in Sweet's

W. H. **NICHOLSON** & CO.
180 OREGON ST., WILKES-BARRE, PA.
Valves • Traps • Steam Specialties

Air Power on Wheels

Abundant, economical air power is yours today and for years to come if you've an Ingersoll-Rand Mobil-Air Compressor working for you. You need less money to operate it . . . less to transport it . . . less to maintain it. The overall cost of compressing air is greatly reduced and a wider field of usefulness provided.

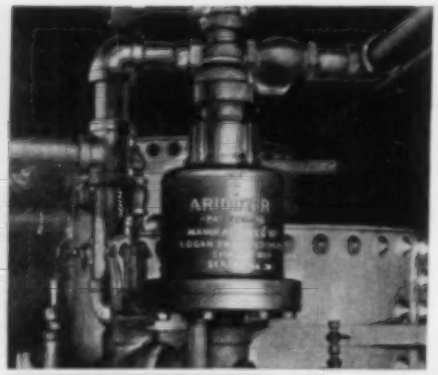
The absolute maximum in anti-friction advantages are available in the Mobil-Air because it is equipped with Timken Bearings on the compressor crankshaft and also on the road wheels. *Timken Bearings provide the utmost in anti-frictionization* which results in smoother operation, reduced wear, lower operating and maintenance costs, greater endurance and longer equipment life.

Remember, if you're thinking of buying a new air compressor don't merely ask for an anti-frictionized compressor. Specify "Timken Bearing Equipped" and get all there is in anti-friction protection! The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



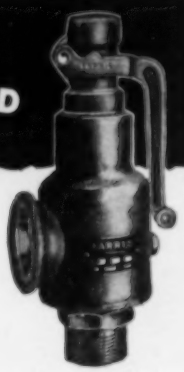
Contamination in Compressed Air Is a Costly Luxury . . . . . .

Moisture, oil and dirt present in all air that comes from air compressors has a destructive effect on air-operated tools and devices. Sprayed finishes are also spoiled by dirty, wet air. The Aridifier completely and continuously removes all contamination from compressed air by centrifugal force. Write for Bulletin 939-A.

LOGAN ENGINEERING CO.
4911 Lawrence Ave. Chicago 30, Ill.
Makers of the Logan Lathe

Logan ARIDIFIER
Dries and Cleans Compressed Air

POPS when it SHOULD pop!



Accurate, dependable popping and tight closing are built into this FARRIS Pop Valve No. 1800. Precision machining of the same calibre that has made all FARRIS Safety and Relief Valves so reliable. Light-weight, but sturdy construction for grueling service and long life. Economically priced.

Specify this FARRIS pop valve and you'll soon see *why* engineers are demanding FARRIS valves for all kinds of safety and relief jobs. We build a complete line to suit most jobs.

Write today for our Specifications Bulletin.

Adjusted popping range, proven accurate and safe. For pressures to 250 lbs. steam. Sizes ½" to 2½".

FARRIS ENGINEERING CO., 354 Commercial Ave., Palisades Park, N. J.

Farris SAFETY and RELIEF VALVES

THIS IS THE HAMILTON AFTERCOOLER SYSTEM ★ GUARANTEED

YES...

Guaranteed like all Murphy products, to do the job . . . *and wear*. Guaranteed to eliminate entirely all moisture from compressed air lines which have heretofore proved stubborn. Entirely mechanical and automatic. No absorbents . . . no chemicals. Install it and forget it.

Murphy *knows* compressed air. Write for our literature, or state your problem. Our engineers are at your service.

WRITE FOR BULLETIN No. 1 CONTAINING SPECIFICATIONS

GUARANTEED COMPRESSED AIR PRODUCTS

AFTERCOOLERS • SEPARATORS • STRAINERS • TRAPS
SPRAY GUNS • PISTOL SPRAYERS

JAS. A. MURPHY & CO.
HAMILTON, OHIO, U.S.A.
Moisture Elimination Up To 3000 Pounds Per Square Inch

APPRECIATION of Quality

Wartime conditions — "victory models" — substitutions for strategic materials — all have made pencil users more and more critical of pencil quality. They look for and expect pre-Pearl Harbor perfection.

Whether it's a pencil or a tool, there is always the demand that it function smoothly, that it perform its task faster over a longer life span.

KOH-I-NOOR always has been and still is the accepted standard for *uniform* quality in pencils—whether it be for the technician, artist, office worker or student.

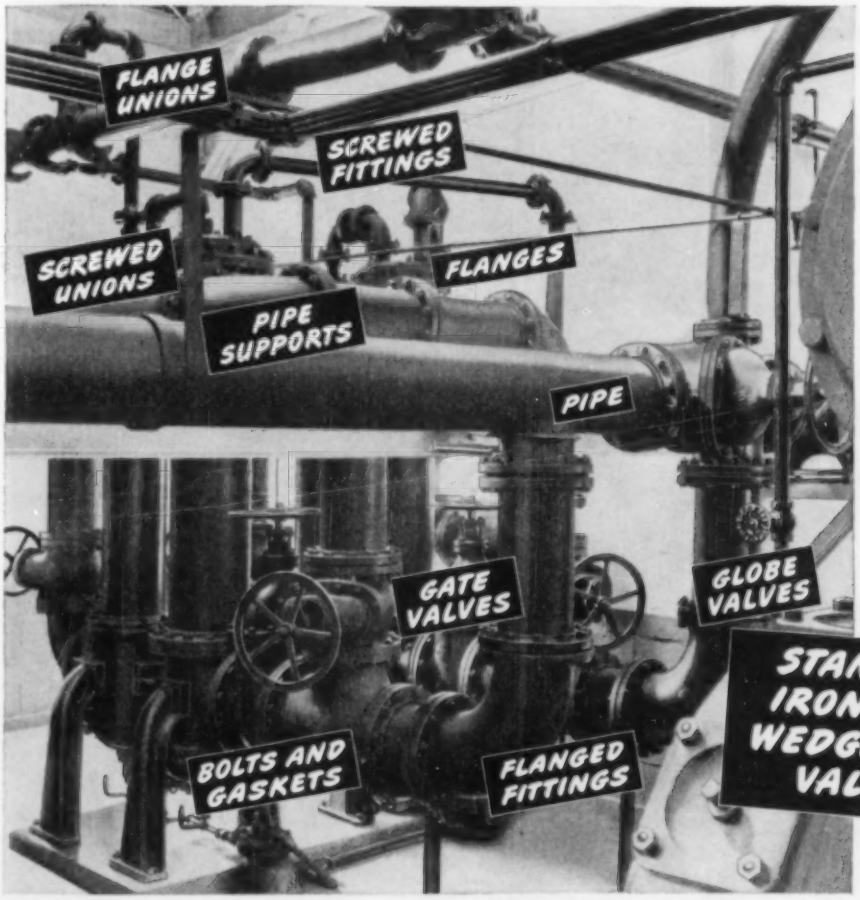
Send For Leaflet No. 19

KOH-I-NOOR PENCIL COMPANY, INC.
Bloomsbury, New Jersey

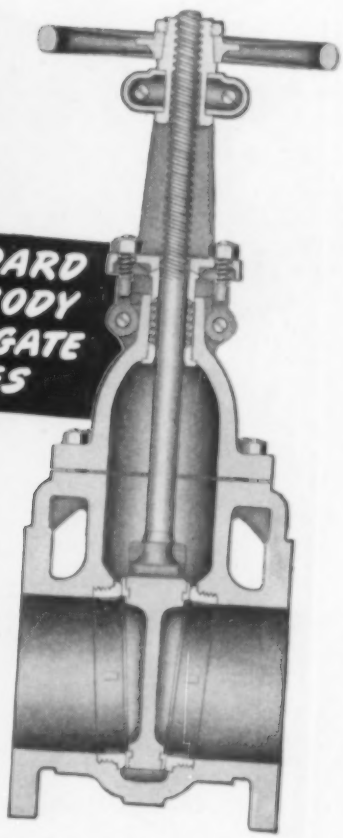
CRANE CAN SUPPLY IT
. . . Whatever You Need in Piping Materials

ONE SOURCE OF SUPPLY
ONE RESPONSIBILITY FOR ALL PARTS
ONE STANDARD OF QUALITY

It's easy to simplify and speed deferred replacement work . . . when you take advantage of Crane *complete* piping materials service. *All* your piping needs are supplied by a single source—your Crane Branch or Wholesaler. You get exactly what you need—you choose from the world's greatest line of piping materials, in brass, iron and steel. Uniform quality in all parts—and one responsibility for them—helps you get the best installations. Crane Co.'s 90 years' experience in meeting piping needs assures your complete satisfaction. In Standard Iron Body Wedge Gate Valves, for example, Crane offers the complete line listed below.



Aftercooler hook-up in Chemical Plant



SERVICE RECOMMENDATIONS: **Crane Standard Iron Body Wedge Gate Valves** with Brass trim are recommended for steam, water or oil lines; all-iron valves for oil, gas or fluids that corrode brass but not iron. Made in O.S. & Y. and Non-Rising Stem patterns.

Working Pressures

Size of Valve	Screwed or Flanged End Valves		Hub End Valves
	Saturated Steam	Cold Water, Oil or Gas, Non-Shock	Cold Water or Gas Non-Shock
2 to 12 in.	125 pounds	200 pounds	200 pounds
14 and 16 in.	125 pounds	150 pounds	150 pounds
18 to 24 in.	*	150 pounds	150 pounds

*For steam lines larger than 16-in., Crane 150-Pound Cast Steel Gate Valves are recommended. (For sizes under 2-in., use Crane Clamp Gate Valves.)

CRANE CO., General Offices: 836 S. Michigan Ave., Chicago 5, Ill. • *Branches and Wholesalers Serving All Industrial Areas*

CRANE — **VALVES • FITTINGS • PIPE**
PLUMBING • HEATING • PUMPS

BOILED DOWN

TO SIMPLIFY MOTOR SELECTION

● This new booklet gives ratings, sizes, characteristics, dimensions, where-to-use data, *and prices* of General Electric a-c and d-c motors, 1/16 to 75 hp. Everything you need to know to select these sizes—all in 16 pages!

Builders of TRI-CLAD Motors

Buy all the BONDS you can—and keep all you buy

GENERAL ELECTRIC

To Save Your Time Later Mail This Coupon Today—

General Electric Company, Schenectady 5, N. Y.

Please send me a copy of your Condensed Motor Catalog (No. GEA-4281).

Name .....

Company .....

Address .....

City ..... **State** .....

750-258-4R8

gear your drives to more efficient power transmission

8 Points of Balance

1. Wide margin of strength.
2. Minimum inelastic stretch.
3. Uniform flexibility.
4. Maximum resistance to structural breakdown.
5. Smooth running.
6. Maximum traction.
7. High resistance to side wear.
8. Correct lateral reinforcement.

These 8 Points are correctly embodied in every Condor V-Belt. Other factors being equal, the useful life of a V-Belt is limited by excessive stretch.

Every Condor V-Belt has these 8 Points of Balance engineered into it — every Condor V-Belt is designed to give you more efficient power transmission, greater production and added profit through longer service life. And every Condor V-Belt does just that.

Stout, tough pre-stretched Whipcords carry the load smoothly, and are the Strength Members that fortify the FLEXLASTICS in which they are embedded. The FLEXLASTICS dissipate the heat of internal friction and high-speed flexing while providing a cushioned, smooth-running V-Belt.

Condor V-Belts are only one of the many MANHATTAN Products in which FLEXLASTICS, with engineered and correctly placed Strength Members, deliver added service. There are Paranite-G.O.P. Oil-Proof V-Belts with the same scientific principle embodied in their construction, but with G.O.P. FLEXLASTICS throughout for service where oil or excessive temperatures exist. The Non-Spark Feature for guarding against danger of fire, explosion and hazards from static is restricted but will be ready for your post-war use.

Write now for Condor V-Belt Bulletin 6868 B.

Condor Belts are now made in the dark, war-time color. The term FLEXLASTICS is an exclusive MANHATTAN trade mark. Only MANHATTAN can make FLEXLASTICS.

ARMY NAVY

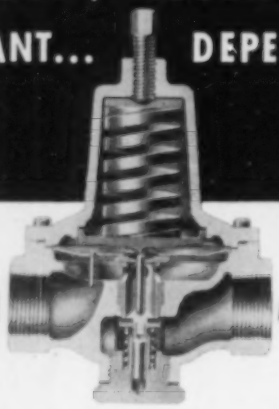
RM

THE MANHATTAN RUBBER MFG. DIVISION

OF RAYBESTOS-MANHATTAN INC.

Executive Offices and Factories PASSAIC, NEW JERSEY

Air Pressure
CONSTANT... DEPENDABLE



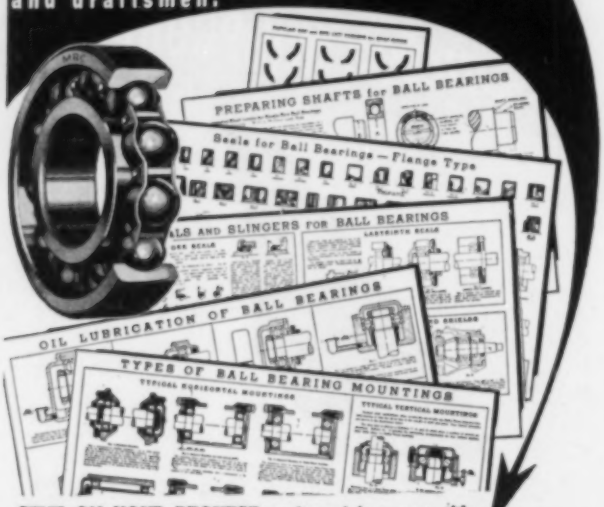
Norgren Regulator Valves in the air line are your best guarantee of constant, even air pressure to any air-driven tools and cylinders.

- **FLOATING DIAPHRAGM** provides flexibility, quick action and long life.
- **BAFFLE PLATE** controls diaphragm, insures decisive opening and closing.
- **SYPHON TUBE** passes greater volume of air or gas with less pressure drop than conventional regulators.

Write for complete information. C. A. Norgren Co., 220 Santa Fe Dr., Denver 9, Colo.

Norgren

27 BULLETINS on Ball Bearings—their use, maintenance and installation. Available to shop men, maintenance men, engineers, designers and draftsmen.

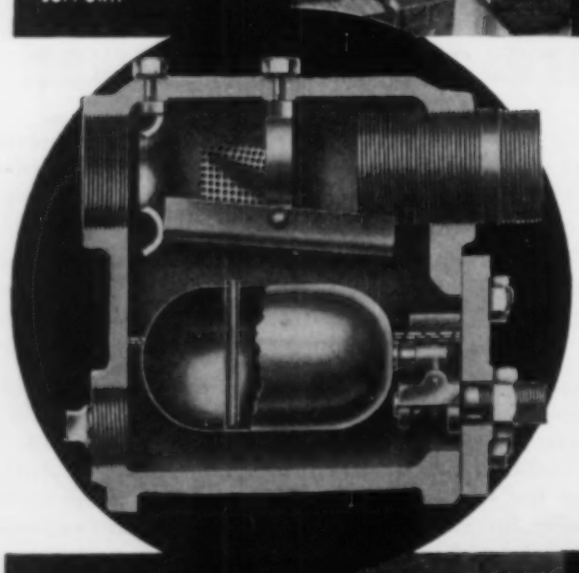

PREPARING SHAFTS for BALL BEARINGS
Seals for Ball Bearings — Flange Type
SHIELDS AND SLINGERS FOR BALL BEARINGS
OIL LUBRICATION OF BALL BEARINGS
TYPES OF BALL BEARING MOUNTINGS

SENT ON YOUR REQUEST; write, giving your title or position and name of company.

M-R-C BALL BEARINGS
MARLIN-ROCKWELL CORPORATION
Executive Offices: JAMESTOWN, N. Y.

DRI AIR MAY BE INSTALLED BY SUSPENDING IT FROM THE PIPING WITHOUT ANY OTHER SUPPORT.

INCREASED PNEUMATIC EFFICIENCY WITH THIS AUTOMATIC SEPARATOR



PROTECT EQUIPMENT WITH

DRIAIR

SEPARATES • COLLECTS • DELIVERS

• DriAir separates and automatically ejects the condensed water and oil from compressed air lines, collects pipe scale and rust, delivers clean dry air to tools and other pneumatic equipment. This promotes better lubrication, reduces wear, increases life of tools and produces greater output. All internal parts are made of bronze or copper—resistant to corrosion and practically permanent.

A TYPICAL INSTALLATION SHOWING DRI AIR STANDING ON A CONCRETE FLOOR NEXT TO THE WALL.

WRITE FOR BULLETIN DA WHICH FULLY DESCRIBES THE CONSTRUCTION AND OPERATION OF THE DRIAIR.

NEW JERSEY METER CO.
"SPECIALISTS IN COMPRESSED AIR DEVICES"
PLAINFIELD, NEW JERSEY

New Model A-1 *Pur-O-fier*

For Compressed Air

Positive purification of air lines is assured with this new Model A-1 Pur-O-fier designed to eliminate free moisture, oil and foreign matter in small compressed air systems. It operates with from 1 to 5 cubic feet of air and for intermittent operations is extremely sensitive to the slightest movement of air. Weighing only 1¼ lbs., this new unit is just 3⅛" in diameter by 5 5/16" deep including plastic, transparent entrainment sump. Model A-1 Pur-O-fier requires no maintenance.

Drain valve permits easy and quick draining of the sump. Pur-O-fier uses positive, centrifugal action as a medium for purification and can be used for air-operated instrument controls, air-operated gauges of the precision and checking type, and air-operated cleaning devices of many types. This unit will operate effectively from 1 to 75 P.S.I. Write for bulletin No. 11 giving complete details.

Patent applied for

Write for New Bulletin No. 11 giving complete specifications and applications

BIRD-WHITE COMPANY
Dept. CA, 3119 W. Lake Street
CHICAGO, ILLINOIS

LOW COST... ECONOMICAL DEPENDABLE POWER for Compressors

ATLAS *LANOVA* **DIESEL**

5 to 15 H. P.

An Atlas Lanova Diesel will help you keep your compressor costs down, and your air supply up by providing economical and dependable driving power for your compressor. Atlas 5 to 15 H.P., one and three cylinder prime movers . . . backed by over 40 years of engine experience . . . are built for hours of continuous and trouble-free service. Unlike many other small engines, this Atlas built unit operates with a minimum of vibration . . . gives maximum power per gallon of fuel. You should have all the facts on how Atlas Lanova Diesels can help you get more from your compressors . . . now. Write today, stating your power requirements.

Also Manufacturers of 30 to 600 H.P. Diesels.

Atlas Imperial Diesel Engine Co.
228 N. LaSalle Street, Chicago 1, Illinois, Room 1210
Branches in Principal Cities, Canada and Alaska

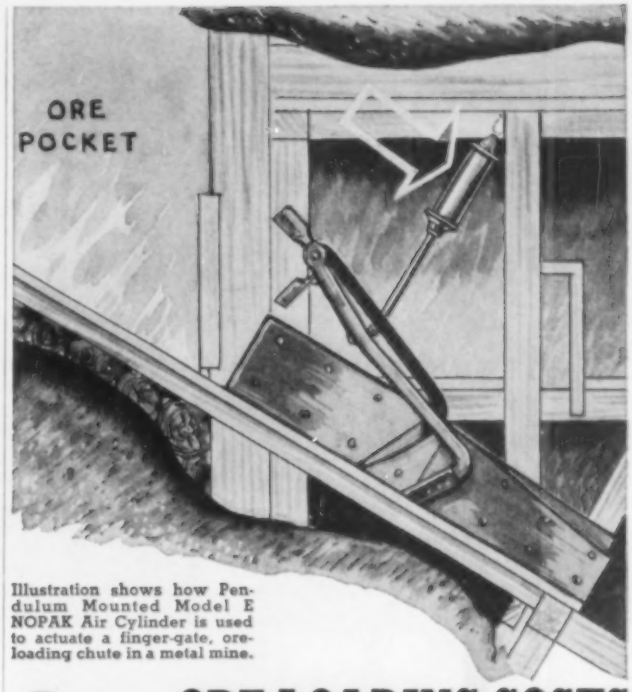


Illustration shows how Pendulum Mounted Model E NOPAK Air Cylinder is used to actuate a finger-gate, ore-loading chute in a metal mine.

Reduce ORE-LOADING COSTS with NOPAK Air Cylinders!

The illustration shows how a heavy-duty NOPAK Air Cylinder may be used to operate a finger-gate loading chute which controls the flow of ore from the ore-pocket to cars or skips. It is typical of the many uses for NOPAK Air Cylinders in ore-handling and *loading* operations.

Mine operators are finding that air cylinder power provides decided advantages over manual or mechanical methods in the operation of heavy doors, bin slides and chute gates. Here are a few of them: —

- Minimizes the hazard of uncontrollable ore-flow from bins, pockets or chutes.
- Keeps haulage ways clean by preventing spills.
- Promotes speedy loading of cars or skips, reducing cost-per-ton of ore moved.
- Reduces maintenance cost of loading chutes.
- Danger of injury to chute tenders is minimized.
- NOPAK Air Cylinders, controlled by NOPAK Cored-Disc Valves, are easy and economical to operate.

NOPAK MODEL E Air Cylinder with Pendulum Mounting. NOPAK Cylinders, both Regular and Heavy Duty are available in 6 Standard Mountings to meet practically all application requirements.

Of course, there are many other uses for NOPAK Air Cylinders and Valves in mining operations. Let us help you with the successful application of air-cylinder power to lifting, lowering, pushing, pulling or clamping operations.

Write for literature and suggestions.

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NOPAK VALVES and CYLINDERS
DESIGNED for AIR or HYDRAULIC SERVICE

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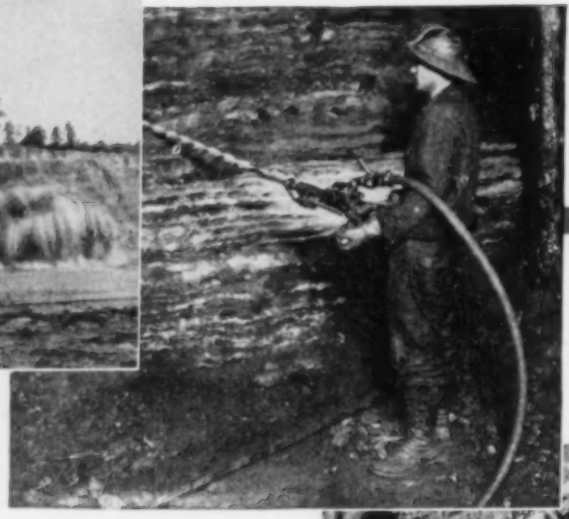

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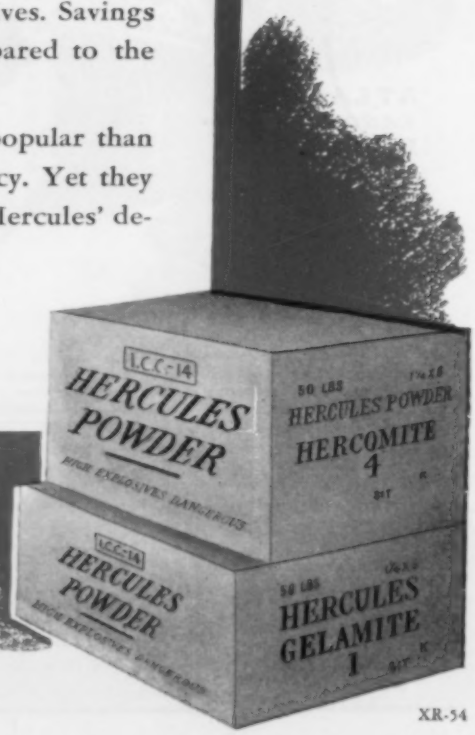

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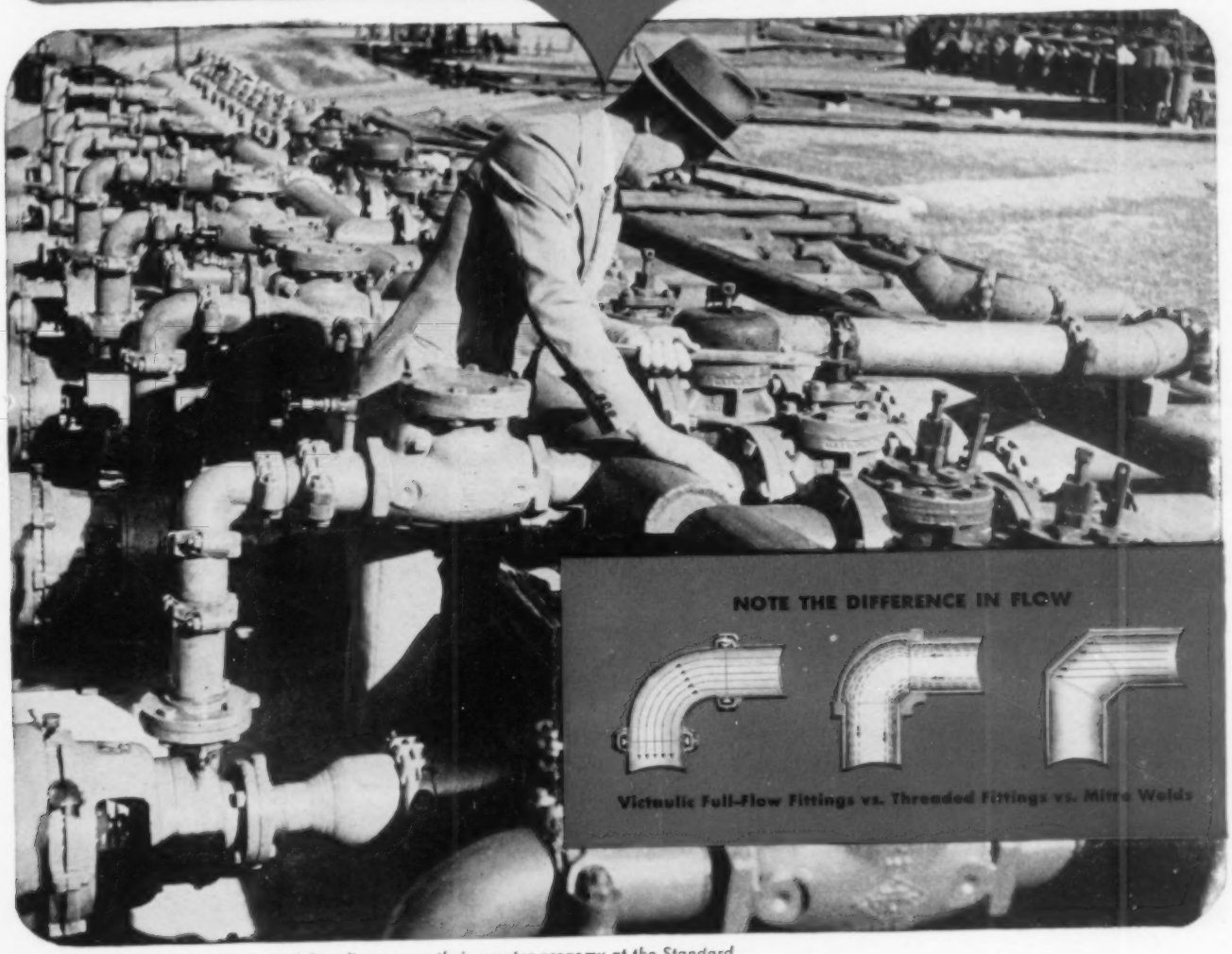

Victaulic Full-Flow Fittings and Couplings prove their greater economy at the Standard Terminal and Bulk Plant, Friendship, N. C.—Standard Oil Company (N.J.) photo.

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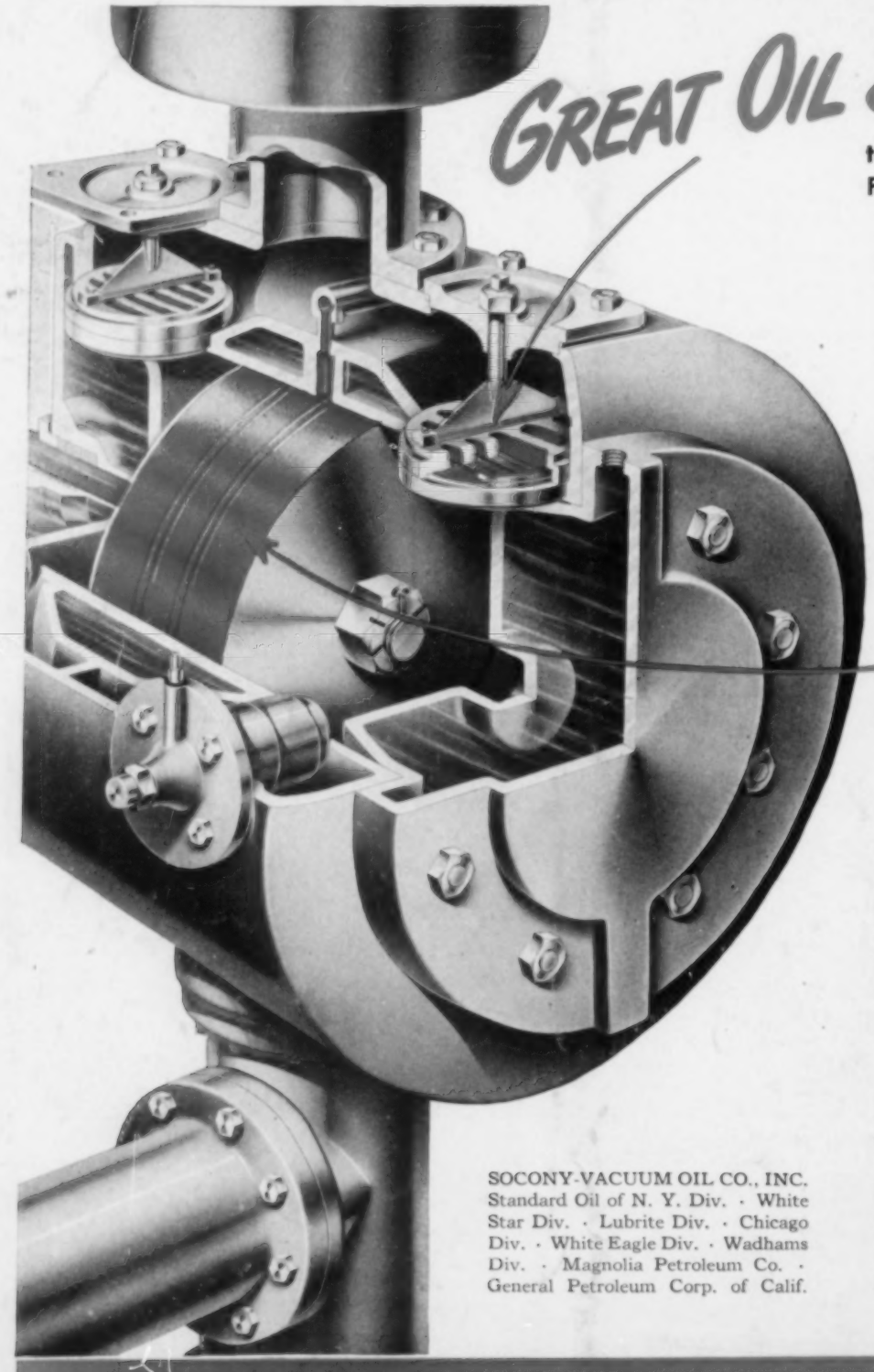

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